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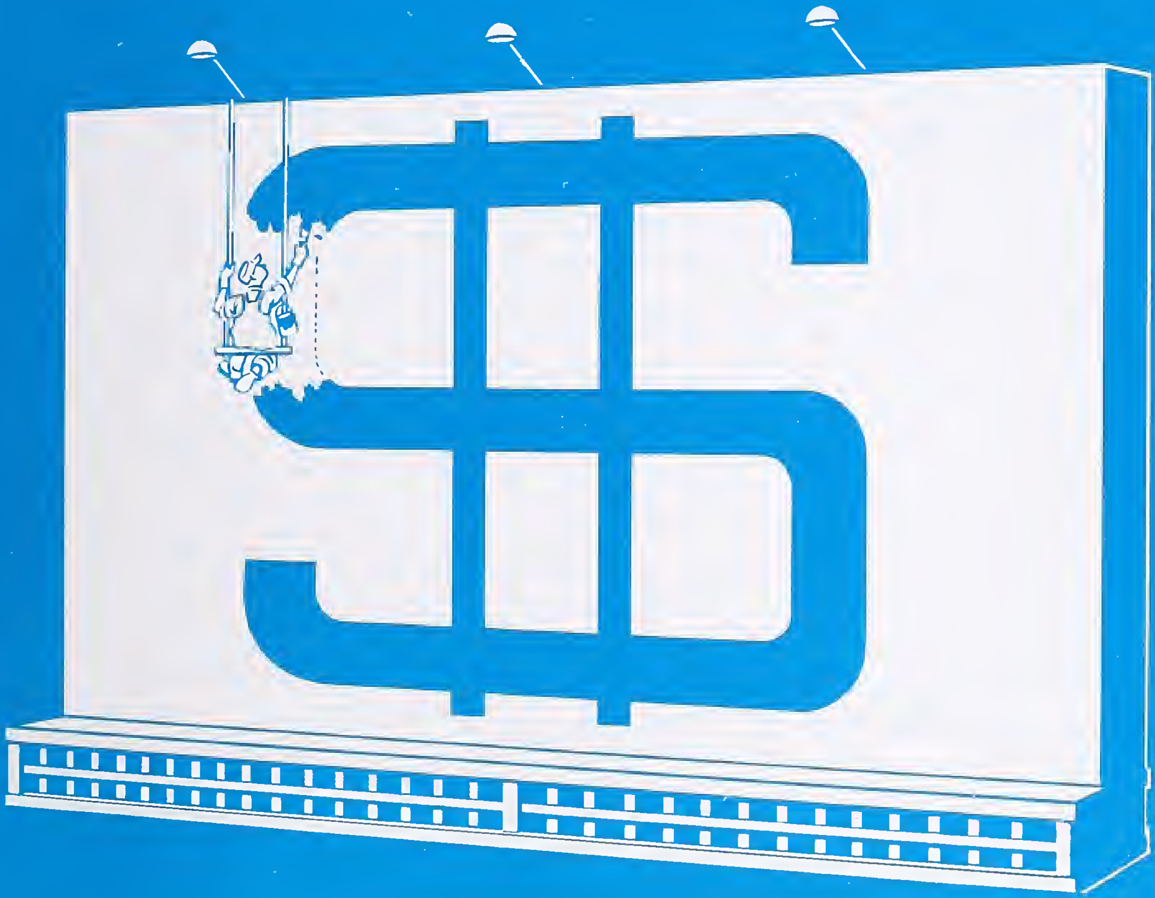
DEPARTMENT OF DEFENSE · UNITED STATES OF AMERICA

defense management JOURNAL



Cost Visibility

April 1974

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Contributing artist for this issue:
Mary L. Field

Comment

by Terence E. McClary
Assistant Secretary of Defense
(Comptroller)

The FY 1975 defense budget request, currently being reviewed by the Congress, is the lowest since 1950. It amounts to 27 percent of the total Federal budget, 5.9 percent of the gross national product, 17 percent of the net total of public spending, and accounts for only 5.2 percent of the total national labor force. All of these measures are the lowest in two decades.

The chart on the next page tells the defense budget story. The dotted line shows the trend in *current* dollars. However, *current* dollars are distorted by inflation and are not a valid measure of *real* resources. To accurately reflect trends over time, adjustment must be made for inflation by selecting a base year and recasting other years in the pay scales and prices of that year. The solid line on the chart does exactly that with FY 1975 as the base year. That line tells the *real* trend in terms of "constant" dollars or dollars of equal purchasing power.

In real terms, the defense budget has remained relatively level from 1973 through 1975. It has declined by more than $30 billion since the peak Vietnam year and is nearly $8 billion less than the last pre-Vietnam year of 1964. The significant fact is, in spite of the *apparent* trend in current dollars, the defense budget is not increasing.

Defense managers must recognize the need to continue management practices which lead to maximizing the return from DOD's limited resources. Only essential items, at the lowest practicable cost, can be included in budget requests and expenditures must be monitored and controlled.

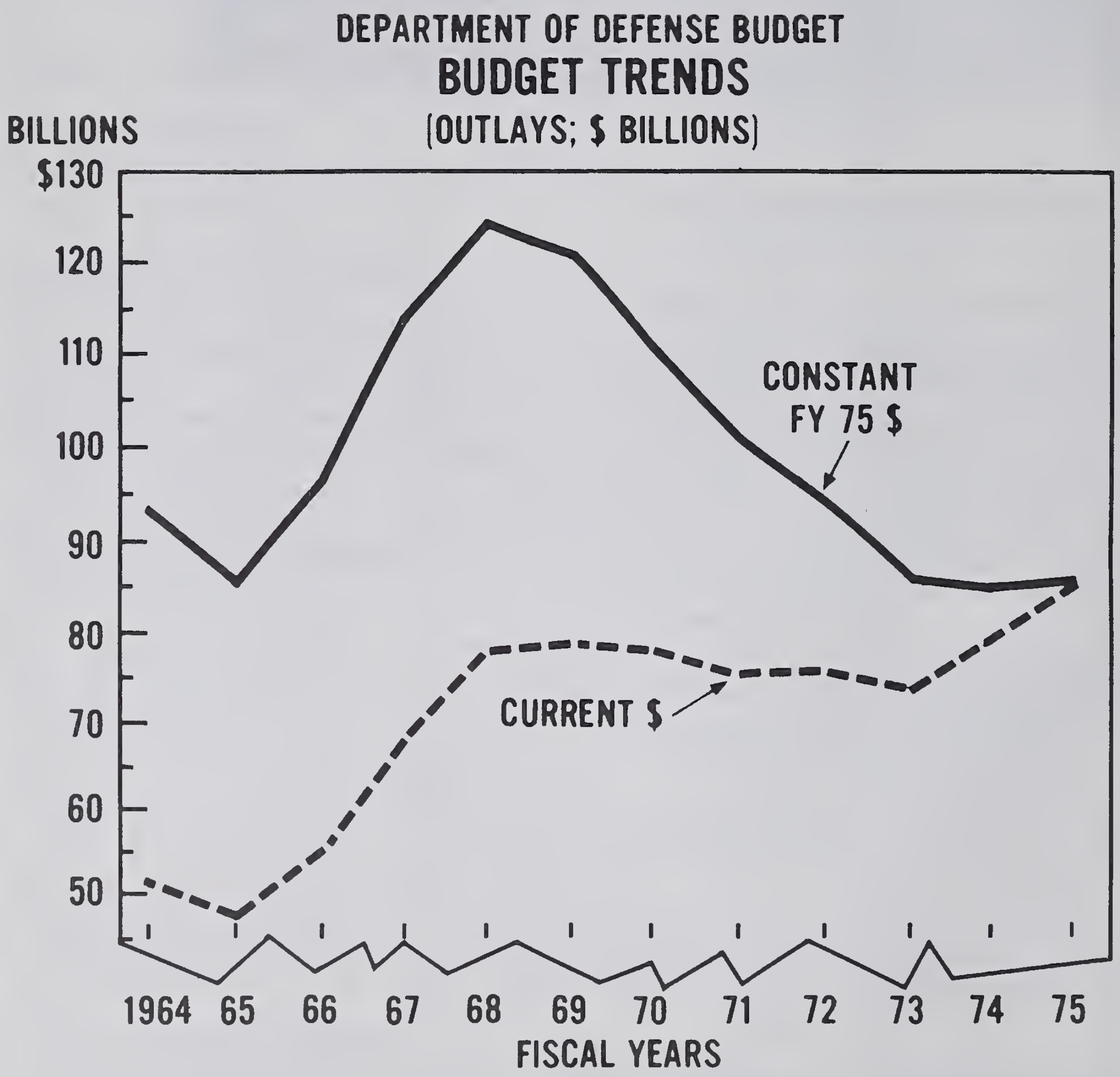
There are several excellent management tools which will assist in this important effort. I would like to underscore two of them. For ongoing work, *program evaluation* will aid financial managers in advising line management of opportunities for economies. For new initiatives, *economic analysis* serves the same purpose. Heavy emphasis is being given to these concepts by my office and I earnestly solicit the participation and support of all echelons of DOD management.

DOD and the Office of Management and Budget are jointly pursuing several overhead and support cost reduction projects which offer considerable potential for improved effectiveness and economy. One project deals with standardization of management systems. For example, DOD has more than 100 different systems for performing the common function of civilian pay. The potential savings in costs of development, maintenance, modification and documentation from standardizing this amalgum are mind boggling.

Another project is aimed at reducing costs by consolidating headquarters organizations. Managers at the operating level can make a valuable contribution by determining the real costs of headquarters echelons and comparing the military value of a given headquarters function to its total cost. There are many other similar areas where opportunities exist for meaningful economies through application of intensive management.

In commenting on the FY 1975 budget, Secretary of Defense Schlesinger said, "This budget bears directly on whether or not the United States will continue to fulfill the responsibilities that it has around the world."

The future holds significant challenges to the defense management community. Let us all ensure that we meet the test.


DEPARTMENT OF DEFENSE BUDGET
BUDGET TRENDS
(OUTLAYS; $ BILLIONS)
BILLIONS
$130
120
110
100
90
80
70
60
50
CONSTANT
FY 75 $
CURRENT $
1964
65
66
67
68
69
70
71
72
73
74
75
FISCAL YEARS

FY 1975 Defense Budget: Settling Down for the Long Haul

Defense budget proposals, of necessity, reflect our perspective on the U.S. role in the world. It is understandable, of course, that there will be divergencies in judgment among Americans on that role, and those divergencies will be reflected in different estimates of what the defense budget should be.

The United States today, as opposed to the period before 1945, bears the principal burden of maintaining the worldwide military equilibrium which is the foundation for the security and the survival of the Free World. This is not a role we have welcomed; it is a role historical necessity has thrust upon us. The burden of responsibility has fallen on the United States, and there is nobody else to pick up the torch if the United States fails to carry it.

In fulfilling this responsibility, we recognize that we are dealing in a world which is militarily dominated by two states—ours and the Soviet Union. There is no other nation that possesses a military capability comparable to these two states. Consequently, in judging the military balance, and in deciding upon our own force posture, we do so primarily with the Soviet Union in mind.

by James R. Schlesinger
Secretary of Defense

Excerpt from Report of the Secretary of Defense to the Congress on the FY 1975 Defense Budget and FY 1975-1979 Defense Program, March 4, 1974.

This does not suggest that we are not hopeful with regard to the future peaceful evolution of world politics; quite the contrary. Considerable progress has been made during the last five years in improving the international political climate. The President has taken many important initiatives: Opening up new lines of communication with the Soviet Union and with the People's Republic of China, helping to settle long-standing disagreements between East and West such as Berlin, beginning in practical ways to put limits on armaments, and ending our military involvement in the hostilities in Indochina. There has been a new spirit of cooperation between East and West, reflected in these practical arrangements, that offers the possibility—as yet it is no more than that—of a more durable peace in the future. U.S. force levels have declined substantially in the wake of these Presidential initiatives and the share of our national resources committed to defense has been significantly reduced.

Neither am I suggesting that the difficulties in the international situation imply there will be an unconstrained arms race or frequent confrontations between East and West. It is precisely to avoid these circumstances, and to put boundaries around arms competition, that we are engaged with the Soviet Union in SALT II. And it is to achieve a similar objective, through a more stable balance at lower force levels in Central Europe, that we and our NATO allies are engaged in negotiations on

Mutual and Balanced Force Reductions with the Warsaw Pact states.

While we pursue negotiations about mutual reductions of arms in furtherance of detente, it is my judgment we must maintain a world-wide military equilibrium. Short of that, we create the possibility of vacuums and temptations that could undermine detente and the hope for improved political relations with the East.

A policy requiring us to maintain our military strength and alliances while we are actively pursuing detente with the Soviet Union and the People's Republic of China may appear to some as incongruous. We have a long tradition in this country of arming with great haste when war comes upon us, and disarming with even greater haste when the war is over; and we have tended, often, to view our relations with other nations in terms of absolutes—friend or foe, ally or adversary, cold war or detente.

Unfortunately, the real world is more complicated. Today, I hardly need argue that a feast and famine approach to national defense is no longer feasible, let alone desirable. Our experience in this century has amply demonstrated that satiating our military establishment in wartime and starving it in peacetime brings us neither peace nor long-term alleviation of the heavy burden of defense. In both blood and treasure, it will cost us less to maintain a reasonably stable level of defense effort until it is possible to achieve genuine mutual reductions in armaments.

The Soviet Union shows that it, at least, sees no inconsistency between detente and increasing military capabilities. We see continuing increases in Soviet budgets, forces and forward deployments. The Soviet Union is making significant improvements in its strategic nuclear forces and, in concert with its partners in the Warsaw Pact, maintains large and ready general purpose forces. These forces are, in fact, the most usable elements of their considerable and diversified military power. We would serve ourselves and our allies poorly indeed if we relied solely on fond hopes or soft words while failing to take practical account of improving Soviet capabilities.

The Soviet Union has historically been a relatively prudent and sober power and I trust it will continue to be so. I hope that as a result of our mutual recognition that there is no good alternative to peaceful cooperation, we shall gradually achieve a world in which security is based upon something more than a balance of arms. But until such a time arrives, we must recognize the need for a stable balance of military forces. As a minimum, we must keep a visible strategic nuclear balance, contribute to a balance of general purpose forces in Central Europe where the bulk of Soviet and Warsaw Pact forces are arrayed against NATO, and together with our allies maintain a balance of naval forces to ensure the freedom of the seas and the protection of our sea lines of communication, as has been the long tradition of the United States.

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Settling Down for the Long Haul

The FY 1975 budget* is our first peacetime defense budget in a decade. It is, therefore, an appropriate time to consider how best to settle down for the long haul, for the continuing, steady task of providing an adequate defense for the United States and its interests. During the next few years, we must search for and assess the best research and development, weapons acquisition and other strategies for the long haul. In doing so, we must ask such questions as how we can most efficiently compete with our major potential opponents, and what constitutes our own major strengths and weaknesses.

In our adjustment to a long haul posture, there are five basic principles which, in my view, should guide the future conduct of the Defense Department:

- The safety of the United States, its citizens and their lawful pursuits continues to depend on the maintenance of a strong defense establishment.
- We have the responsibility, not only to the United States itself but also to our friends throughout the world, to assure the military balance so necessary to deterrence and a more enduring peace.
- The men and women of the Defense Department are without peers as servants of the Nation. It does not follow, however, that patriotism can proceed without respect. We must give them the respect, dignity and sup-

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**Financial tables relating to the FY 1975 defense budget appear on pages 11 to 14.*

port that are their due. Equal opportunity will continue to be a DOD watchword.

- To stress our needs is not to ignore an equal obligation, to use our citizens' resources wisely. We must continue to improve the efficiency and effectiveness of our forces and to add to the arsenal of deterrence.
- We can and must become increasingly competitive with potential adversaries in a more fundamental sense. We must not be forced out of the market—on land, at sea or in the air.

I cannot say at this juncture exactly what the long haul holds for the Defense Department. But I can say that unless we are to plan only by intuition, we must continue to build our peace structure on the hard facts of the international environment rather than on gossamer hopes for the imminent perfectability of mankind.

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Planning and Management Guidance

Deputy Secretary of Defense Clements and I decided to continue the practice of our immediate predecessors and give the military services budget guidance rather than detailed force guidance.

Budget guidance, in our view, together with my general defense planning guidance and the military planning guidance of the Joint Chiefs of Staff encourages the military services to analyze more fully the trade-offs between alternative uses of resources. Naturally, this guidance takes into account the needs of DOD as a whole. . . .

We have continued the Planning, Programming and Budgeting System (PPBS) essentially unchanged in preparing the FY 1975 program and budget. . . . We are examining the PPBS system, however, to see how it can be strengthened and, particularly, whether or not it is possible to achieve better coverage of the support area within the PPBS.

We also have begun a management by objectives (MBO) program to focus top management attention on a key list of specific management objectives we expect to accomplish, primarily in the support area. The MBO program is being used to supplement PPBS and to provide a "results" oriented approach to DOD management.

We also are trying to improve the communication and interchange with the Congress on management issues and data. For example, among the most important elements of our reporting system are the Congressional Data Sheets and the Selected Acquisition Reports (SARs). In December 1973, I initiated a review of the SAR system and directed the results be discussed with interested Congressional committees prior to any substantial change in the system. Our goal in the review is to streamline the SAR so it can be fully responsive to DOD management needs as well as providing Congress with the timely information it needs and desires.

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Force Modernization

We have said that we want to keep force structure to maintain perceived balances. To do so, we also want to keep pace with potential adversaries in modernization. At the same time, there is a need to maintain a certain average age of systems in the force. However, the rising costs of our newer weapon systems, the relatively modest increases in real value of the DOD budgets, and some previous postponements or other delays in modernization (notably those that arose during the war in Southeast Asia) have led to a significant aging problem in the force. The aging problem is seen in the increasing approach to the end of service life of particular force elements, (*i.e.* bloc obsolescence), retirements without replacement, greater maintenance backlogs and funding requirements, and extensions of expected service life. Aging leads to significant pressures on force structure, for systems either wear out and are withdrawn from the force without replacement, or they are replaced on a less than one-for-one basis by significantly more costly systems.

Various solutions to this problem have been discussed, such as "high/low" mixes of systems, increased procurement funding, reduction of force structure where possible, and better management during the development and procurement cycle to reduce the unit costs of systems.

We have conducted studies of this problem in the past year. One significant effort has been to have the military services draft "extended planning annexes" which look at modernization in the force beyond the present planning period, *i.e.* FY 1980 and beyond. These extended planning annexes have been used by the military services to estimate the impact on forces in the 1980's of a constrained level of budget in constant dollars. The major variables for trade-offs in these studies were force, age and size as well as the unit costs, leaving aside consideration of performance against the future threat. Thus we have made the assumption that the presently planned force structure is generally appropriate for the foreseeable future. The studies also assumed that maintenance requirements of new equipment will be the same as those for current equipment (probably optimistic), and assumed in some cases (such as Navy fighters) that new systems will cost less than those currently being procured. These studies have also left aside the possibility of radical changes to the defense budget or the demands of any conflicts that might occur. The studies concentrated on major acquisitions which constitute about 65 percent of total procurement. Thus the Army reviewed in detail about $2 billion of its annual assumed procurement budget, the Navy about $7 billion, and the Air Force between $3 and $4 billion, depending on the year. The remaining procurement funds would support other procurement (munitions, spares, modifications, etc.).

The conclusions reached in these studies were that our General Purpose Forces tended to age throughout the next 15 years. Major exceptions were tanks and airlift aircraft. These exceptions were also the only cases in which the average age of the systems was maintained at half the expected service life. All other major categories of systems tended to age at a significant rate. The most pressing problem is the tactical air forces where the military services now project much longer system life than history would suggest is realistic. This assumption requires further study before acceptance. But whatever the assumption, the age of tactical aircraft is increasing at nearly half a year per year, resulting in an average force age of over 10 years by 1985, in comparison to the current age of less than six years.

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We have attempted to make some estimates of the resources needed in the 1980–1985 period to stabilize the aging process for all major classes of weapons, and suspect that as much as a $1 to $2 billion increase in major procurement funding may be needed in that period to stop the aging process if no force level changes are made. Rolling back the age of equipment would take more and would depend on how long we wait.

. . . We will also set long-term force level goals and realistic long-term funding expectations. Certainly more stability in planning defense resources that we have had heretofore would be of assistance. Whether the international situation, conflicts or domestic considerations will permit this remains to be seen. We are also attempting to reduce the age of weapon systems by the following measures:

- Establishment of the Cost Analysis Improvement Group (CAIG) in January 1973 to provide improved independent cost analysis in the military services and OSD.
- Design to a Cost. Production unit costs have been established by defining unit cost thresholds in the Development Concept Paper (DCP) approved by the Deputy Secretary of Defense. The cost threshold obligates the program manager to attempt to develop a weapon system that can be acquired within the cost threshold.
- "Fly Before Buy." Operational test and evaluation (OT&E) before production has received major emphasis with the establishment of a Deputy Director of Defense Research and Engineering for T&E. DOD directives now require an initial operational testing phase prior to the production decision. This should reduce the need for costly modification and retrofit programs after production initiation and should increase the probability of avoiding major failures in production systems.
- Prototype Programs. A few prototype development programs have been initiated which may provide low-cost procurement options without requiring in advance a commitment to procurement.
- Low-Cost Systems Development. Systems such as the A–10, patrol frigate, and sea control ship were conceived as low unit cost weapon systems.

The program we have presented this year should enable us to keep the greater part of the present force structure while making significant progress in replacement and modernization. However, we have some indications of significant aging problems which will come upon us in the future, particularly in the 1980–1985 time period. This may require some significant changes in procurement programs in the coming years.

Weapons Acquisition Process

We are preparing three experimental Mission Concept Papers (MCPs) on strategic offense, continental air defense and theater air defense. These papers are planning documents designed to provide an understanding of the broad functional and fiscal context into which proposed new systems should fit during their development, acquisition and operational life. The MCPs include assessment of the threat, resources currently projected as available for the specific mission area, potential military needs and major deficiencies in projected operational capabilities. They will have the following uses in the procurement of new weapon systems:

- Early identification of new technology required.
- Aid in setting unit cost targets and evaluation of affordability.
- Planning for efficient use of the industrial base.
- Estimating resource allocation and availability.
- Scheduling weapon system development and replacement, including force implications of new developments.

Cost Reduction

To decrease the cost associated with the greater performance demanded of replacement weapon systems, we are making a sharp distinction between systems that are needed and those that are "nice to have." As obvious as this sounds, its implementation requires that we have clearly established force objectives and requirements. We are doing this in Development Concept Papers (DCPs) and within the Defense Systems Acquisition Review Council (DSARC). We are structuring our forces with the high/low force mix concept. For a particular mission, we would have a small number of high-performance, sophisticated weapons capable of coping with the maximum enemy threat and a larger number of less sophisticated and less expensive but capable weapons for countering the lower capability enemy threats.

We are changing our weapons acquisition objectives from an emphasis on improving the state of the art in performance to an emphasis on quality equipment having an acceptable performance for an affordable cost. When a requirement for a particular weapon system is objectively substantiated, we ask how this need can be satisfied as economically as possible. Controlling of sophistication must be accomplished very early in the weapon system life cycle process. We cannot afford unnecessary items in any system, and we must adhere to the requirement that any post-contract design changes be tied to decisions on dollar availability.

Having decided on design essentials, the designer must focus clearly on unit production costs, as well as on the cost of operating the system, before the design goes into production. In order to do this, we have tasked "Request for Proposal (RFP)/Contracts Requirement Review Boards" set up in all military services to examine RFPs and contracts to ensure:

- Minimum use of exclusive military material specifications in favor of more general commercial standards and practices where practicable.
- Promotion via RFPs of full use of "off-the-shelf" and/or standardized components developed for either military or commercial use.
- Maximum flexibility allowance in contractor design to encourage trade-offs in performance, schedule or other specifications for savings in acquisition or life cycle costs.

We have developed a design to a cost concept within DOD that makes cost, along with performance and schedule, of primary management concern throughout the acquisition process. . . .

With design to a cost, the military services and their project managers will have the authority to make the performance and schedule adjustments necessary to achieve cost goals. For future programs, a design to a cost estimate will be established at the earliest possible date, but not later than entry into the full-scale development phase of the acquisition process.

A Cost Analysis Improvement Group (CAIG) was established within OSD to assess the reasonableness of cost estimates and the criteria used in their development. At the same time, each military service has developed a staff component capable of preparing independent parametric cost estimates. These service components, working with the OSD Cost Group, prepare an independent cost analysis each time a weapon system is reviewed by the DSARC.

The CAIG is still too new to assess fully the effect it will have, if any, on reducing cost growth. Some results, however, already are evident. The development of a separate cost estimate, free from the optimism and pressures of the program advocacy channels and using different techniques, has provided an independent and objective check on the reasonableness of the project manager's estimate. Perhaps the most important benefit, however, has been that conflicting cost views become visible at the top level, thus allowing free and open discussion of the cost issues involved in defense systems procurement at the highest policy levels before important decisions are made.

We are emphasizing the use of new technology for reducing costs and improving reliability as well as for increasing the performance and range of capability for our weapon systems. New technology is useful, however, only when it becomes a proven scientific or engineering capability ready for application. . . . New technology can be used directly to save money by:

- Simplifying design, decreasing materiel and manufacturing costs and increasing shelf or service life.
- Improving safety and ease of handling of weapons, equipment and material thus decreasing the logistic and maintenance support required.
- Providing knowledge and the apparatus necessary to automate manufacturing and logistic operations to gain manpower savings.

New technology can be applied indirectly to save money through increases in effectiveness of weapon systems or through design of modular components useful in more than one weapon system.

Within a relatively fixed total DOD budget, any savings from technology applications will hopefully be realized in the form of military potential retained in the face of an increasingly competitive environment. Such savings could help to keep us from "pricing ourselves out of the market." Savings in the form of retained capability are not easily measured and, consequently, are hard to prove. They are nevertheless real and important. New technology will yield savings only if we take a hard line in limiting the application to meeting truly essential requirements in efficient ways. This we intend to do.

Program Managers

The success of a major weapon system acquisition program is determined not only by our ability to acquire equipment which meets the stated technical performance objective within planned schedules and costs, but also by how effectively the system operates in combat and by its ability to be supported and maintained in the field. The program manager's responsibility encompasses all these aspects of weapon system development and acquisition. Experience, good judgment, and a long tour in the assignment are essential if the program manager is to meet these responsibilities successfully. . . .

To ensure the military services continue to place a high priority on acquiring and keeping able people as program managers and the program managers are given the authority, responsibility and accountability required to successfully accomplish their tasks, we have formulated a program manager objective as part of the management by objective program. It consists of:

- Increased emphasis on education and experience in selection of program managers.
- Greater promotional opportunities for program managers.
- Equating major program managers with major commands in terms of career enhancement.
- Rotation of program managers to coincide with program milestones rather than an arbitrary date. This allows longer tenure for program managers.
- Clearly defined charters from higher authority to the program manager delineating his range of authority and responsibility.
- Accountability to higher authority by the program manager for the successful and timely completion of program milestones.

* * *

Standardization of Management Systems

Many of the basic characteristics of management systems within DOD are common to more than one component. Significant advantages can be realized if these management systems are standardized with respect to system design and related automatic data processing equipment and procedures. Among the advantages are more effective use of limited personnel resources with hard-to-find talents, reduced training requirements, ease of audit and management review. . . . Our particular targets are those different systems operated by different components to perform essentially identical functions. Differences which are essential to satisfy inescapable variations in component missions will be accommodated, but unnecessary differences, which exist only because of long-term usage, will not be tolerated.

As part of our management by objectives program, we have established a task force under the direction of the Assistant Secretary of Defense (Comptroller) to standardize defense management systems where standardization will reduce systems development or maintenance costs, or operating costs, without sacrifice of support essential to management.

Support Cost Accounting

Support costs in general are not accounted for along weapon system or support system lines. It is not possible with the present DOD management and accounting system to find out, without a specific large-scale study, how much we spend to support specific weapon systems. Nor is it possible to assess easily the impact on readiness of alternative budget allocations which relate to these costs. Present management guides and controls are inadequate to give confidence that reductions do not impact readiness.

The DOD management and accounting system is designed primarily to identify costs organizationally and functionally. In the interest of more efficient management of the resources used in operations and maintenance of weapon systems, we believe it is necessary to have cost-effective management and accounting of support costs by weapon support system. The break-out of operation and maintenance cost by weapon or support system is necessary to meet our major goal of optimum readiness within budget constraints. While there have been previous efforts to establish equipment maintenance cost accounting by weapon support system, these have been limited in scope and implementation is only partially complete.

As another one of our management by objectives actions, we have established a task group to consider management focus, data needs, data systems and cost, system uniformity and phasing of implementation to develop a system to identify maintenance and other operation costs by weapon or support system.

Logistic Support Aspects

The improvement of reliability, maintainability and life cycle support of new weapons is receiving increased emphasis within DOD. Logistic support is a major design parameter with the objective of reducing the number of equipment failures, cutting repair costs, and decreasing distribution and inventory costs of components through greater standardization. To assure design objectives are reached and required logistic planning has been accomplished, a plan for logistic support has been made an integral part of weapon system development plans. Demonstration that logistic design parameters have been achieved is a major objective of developmental and operational testing and evaluation. System program managers have been charged with the responsibility for assuring that support resource requirements are integrated with operational requirements to accomplish successful deployment of new systems.

Logistics Systems Management

* * *

On October 1, 1973, implementation of the plan for worldwide integrated management of subsistence stocks began. This plan consists of two phases: Phase I brings all wholesale stocks into an integrated management system and Phase II extends that system to all retail stocks. The Defense Supply Agency (DSA) will be authorized overall policy and direction in the area of inventory management of wholesale subsistence stocks. Despite this fundamental change, requisitioning procedures for ships and units remain the same and thus little disruption or confusion will be caused at the user level. The integrated nature of this system will allow us to be more fully aware of what we need, what we have, where it is and how to move the DOD subsistence stocks most efficiently.

A plan to integrate the DOD property program on a worldwide basis became a reality on July 1, 1973, when the Headquarters of the Defense Property Disposal Service (DPDS) became fully operational. DSA will exercise overall responsibility for the program to include centralized policy direction, inspection and audit functions. Program management and staff supervision are to be exercised by the DPDS. Major features of this integrated management effort are worldwide inventory management, worldwide management information and a centralized accounting system.

Inventory Management

The support of U.S. armed forces is expensive in terms of materiel costs and management effort. The use of improved technology in communications, automation, transportation and distribution will offset some of the funding problems. Innovative management can provide economical support without disrupting essential missions. Our military supply system must include only the minimum number of items required for effective military operations.

A program for eliminating duplicate management of consumable items in DOD is now in effect. The responsibility of each military service to procure and manage the items it needs and uses has resulted in the past in competition between the services for procurement of available materiel. With the advent of an integrated materiel management of consumable items program, a single manager is designated to assume total wholesale logistic support responsibility for all users of a single item. He is no longer an Army, Navy or Air Force manager exclusively. He has become a DOD manager obligated to provide impartial support to all military service customers. The effort marks a major milestone in attaining a logistics objective of one item/one manager.

While management responsibilities have been determined for all consumable items, there still remains the task of transferring responsibilities and inventories from one or several managers to another. A special joint task group is monitoring the completion of the logistics support responsibility realignments.

Productivity Program

In August 1973 Deputy Secretary of Defense Clements established a DOD productivity program under the leadership of the Assistant Secretary of Defense (Installations and Logistics). The objectives of the program are to:

- Promote productivity improvements at all levels of responsibility throughout DOD.
- Foster the development and use of productivity measurements.
- Establish a working environment giving full consideration to meaningful and mature worker/manager relationships in which both can fully participate and realize mutual benefits.

The program includes coordination of productivity improvement efforts within DOD and development of a management information system which will provide useful productivity data for DOD management purposes.

Management efforts in the productivity program are geared toward workload stabilization, procedures simplification, organization realignments, application of human engineering and productivity improvements through capital investments. All of these efforts are necessary to offset the increased cost of personnel.

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Energy Management and Conservation

DOD energy consumption represents a $2.5 billion item in our FY 1974 budget, mostly to be spent for procurement of petroleum fuels. Recognizing that this area represented a prime opportunity for economy and better control of fuel distribution, we placed bulk petroleum fuels under integrated management control as of July 1, 1973. This was implemented through the transfer of personnel and petroleum stocks, excluding "on-base" stocks, to the Defense Fuel Supply Center of the Defense Supply Agency.

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In September 1973, the Defense Energy Task Group was established to conduct a comprehensive study to define DOD energy-related problems and to recommend measures for strengthening the management of DOD energy resources. As a result of that study, a Director for Energy, reporting directly to the Assistant Secretary of Defense (Installations and Logistics), has been established with overall program manager authority for this vital resource.

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While we shall continue to share the same hardships and sacrifices being borne by other sectors of the Nation in our housekeeping and administrative support elements, we must have sufficient fuel for our combat forces to remain operationally ready. To assure this, we shall seek priority allocation under the Emergency Petroleum Act of 1973 whenever operational readiness is required.

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Financial Summary

FY 1975 Department of Defense Budget

(Millions of Dollars)

	FY 1964	FY 1968	FY 1973	FY 1974[a]	FY 1975[b]
Summary by Functional Classification					
Military Personnel	12,983	19,939	23,639	24,452	25,898
Retired Military Personnel	1,211	2,093	4,392	5,164	6,014
Operation and Maintenance	11,693	20,908	22,148	24,156	26,596
Procurement	15,036	22,550	18,574	18,653	19,867
Research, Development, Test, and Evaluation	7,053	7,264	8,020	8,333	9,389
Military Construction	977	1,555	1,464	1,821	2,150
Family Housing and Homeowners Asst. Prog.	602	614	1,009	1,148	1,273
Civil Defense	111	86	82	82	86
Special Foreign Currency Program	—	—	3	3	3
Naval Petroleum Reserve	—	—	—	—	24
Military Assistance Program	989	588	1,120	3,295	1,279
Total—Direct Program (TOA)	50,655	75,597	80,452	87,105	92,579
Summary by Program					
Strategic Forces	8,505	7,236	7,253	6,883	7,628
General Purpose Forces	16,406	30,375	25,810	27,899	29,183
Intelligence and Communications	4,378	5,551	5,683	5,949	6,464
Airlift and Sealift	1,044	1,756	860	973	1,053
Guard and Reserve Forces	1,768	2,196	3,897	4,385	4,796
Research and Development	4,813	4,277	6,463	7,003	8,409
Central Supply and Maintenance	4,639	8,422	8,643	8,873	9,330
Training, Medical, Other Gen. Pers. Activ.	6,959	12,183	16,361	18,193	20,078
Administration and Assoc. Activities	1,077	1,237	1,719	1,849	2,164
Support of Other Nations	1,066	2,364	3,762	5,098	3,474
Total—Direct Program (TOA)	50,655	75,597	80,452	87,105	92,579
Summary by Component					
Department of the Army	12,275	24,972	21,656	22,096	23,618
Department of the Navy	14,458	20,765	25,425	27,575	29,568
Department of the Air Force	19,958	24,917	24,707	25,523	28,029
Defense Agencies/OSD	1,007	1,519	2,008	2,165	2,649
Defense-wide	1,857	2,750	5,454	6,399	7,350
Civil Defense	111	86	82	82	86
Military Assistance Program	989	588	1,120	3,295	1,279
Total—Direct Program (TOA)	50,655	75,597	80,452	87,105	92,579

[a] Amounts for proposed legislation for the volunteer force, military retired pay, and flight pay are distributed ($99 million).

[b] Amounts for military and civilian pay increases, and military retired pay reform, volunteer force and other proposed legislation are distributed ($2,242 million).

Note: Details may not add to totals due to rounding.

OASD (Comptroller)

Direct Budget Plan (TOA), Budget Authority and Outlays

FY 1975 Department of Defense Budget

(Millions of Dollars)

Functional Classification	Department of Defense—Total		
	FY 1973	FY 1974	FY 1975
Military Personnel			
Active Forces	22,060	22,647	22,859
Reserve Forces	1,579	1,719	1,742
Total—Military Personnel	23,639	24,366	24,601
Retired Military Personnel	4,392	5,151	5,688
Operation and Maintenance	22,148	24,156	26,044
Procurement			
Aircraft	5,728	6,524	6,797
Missiles	3,106	2,767	2,767
Ships	2,962	3,493	3,563
Combat Vehicles, Weapons & Torpedoes	528	628	679
Ordnance, Vehicles & Related Equipment	3,042	2,147	2,314
Electronics & Communications	1,115	1,318	1,415
Other Procurement	2,092	1,776	2,333
Total—Procurement	18,574	18,653	19,867
Research, Development, Test & Evaluation			
Military Sciences	460	436	441
Aircraft	1,851	1,682	1,829
Missiles	2,130	2,125	2,353
Military Astronautics	407	594	527
Ships & Small Craft	620	635	728
Ordnance, Vehicles & Related Equipment	370	471	513
Other Equipment	1,543	1,664	2,095
Program-wide Management—Support	639	726	836
Total—Research, Development, Test & Evaluation	8,020	8,333	9,322
Military Construction	1,464	1,821	2,150
Family Housing	1,009	1,148	1,273
Civil Defense	82	82	86
Special Foreign Currency Program	3	3	3
Naval Petroleum Reserve	—	—	24
Pay Increase/Retired Pay Reform	—	35	2,089
Volunteer Force Legislation	—	64	153
Total—Military Functions	79,332	83,811	91,300
Military Assistance	1,120	3,295	1,279
TOA Total—Department of Defense	80,452	87,105	92,579
Financing Adjustments	−1,758	−931	−76
Trust Funds & Offsetting Receipts	1,711	753	396
Budget Authority (BA)	80,404	86,928	92,899
Outlays	73,828	79,500	85,800

Department of the Army			Department of the Navy			Department of the Air Force			Defense Agencies /OSD/OCD/MAP/ Undistributed		
FY 1973	FY 1974	FY 1975	FY 1973	FY 1974	FY 1975	FY 1973	FY 1974	FY 1975	FY 1973	FY 1974	FY 1975
7,685	7,762	7,915	7,039	7,397	7,494	7,336	7,488	7,450	—	—	—
994	1,102	1,112	301	288	283	284	329	347	—	—	—
8,680	8,863	9,027	7,340	7,686	7,777	7,619	7,817	7,797	—	—	—
—	—	—	—	—	—	—	—	—	4,392	5,151	5,688
7,433	7,509	7,726	5,939	7,298	7,987	7,279	7,734	8,394	1,497	1,615	1,937
114	187	340	2,974	3,061	2,961	2,640	3,276	3,497	—	—	—
700	642	459	720	663	697	1,686	1,462	1,611	—	—	—
—	—	—	2,962	3,493	3,563	—	—	—	—	—	—
243	351	385	285	277	294	—	—	—	—	—	—
1,330	1,096	1,221	885	596	581	827	455	512	—	—	—
197	469	311	629	453	531	228	342	493	60	54	80
402	206	600	663	574	644	1,018	984	1,067	10	12	22
2,987	2,951	3,315	9,119	9,117	9,270	6,399	6,519	7,179	70	66	102
148	117	112	128	134	138	131	129	131	52	56	60
193	296	270	374	270	349	1,284	1,117	1,210	—	—	—
908	821	706	807	992	1,153	341	242	419	74	69	75
17	18	16	50	53	39	339	524	473	—	—	—
—	—	—	620	635	728	—	—	—	—	—	—
192	255	264	66	85	92	111	131	157	—	—	—
371	402	562	341	418	479	527	517	678	304	327	375
56	63	56	154	157	284	386	466	451	43	41	45
1,885	1,970	1,986	2,542	2,743	3,262	3,120	3,126	3,519	473	493	556
671	773	847	486	704	665	289	299	582	17	45	56
—	—	—	—	—	—	—	—	—	1,009	1,148	1,273
—	—	—	—	—	—	—	—	—	82	82	86
—	—	—	—	—	—	—	—	—	3	3	3
—	—	—	—	—	24	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	35	2,089
—	—	—	—	—	—	—	—	—	—	64	153
21,656	22,067	22,901	25,425	27,547	28,985	24,707	25,495	27,471	7,544	8,702	11,942
—	—	—	—	—	—	—	—	—	1,120	3,295	1,279
21,656	22,067	22,901	25,425	27,547	28,985	24,707	25,495	27,471	8,664	11,997	13,221
−564	−387	−4	−294	−281	—	−753	−203	—	−147	−61	−72
−44	−42	−43	−34	−96	−225	−20	−20	−20	1,809	912	684
21,048	21,638	22,854	25,097	27,170	28,760	23,934	25,272	27,451	10,325	12,847	13,833
20,185	21,262	21,426	22,470	24,241	26,213	23,627	24,411	25,487	7,546	9,586	12,674

OASD (Comptroller)

Obligation Authority, Budget Authority and Outlays

FY 1975 Department of Defense Budget
(Millions of Dollars)

	Direct Budget Plan (TOA)			Budget Authority (BA)			Outlays		
Functional Classification	FY 1973	FY 1974	FY 1975	FY 1973	FY 1974	FY 1975	FY 1973	FY 1974	FY 1975
Military Personnel									
Active Forces	22,060	22,647	22,859	22,075	22,646	22,859	21,722	22,448	22,704
Reserve Forces	1,579	1,719	1,742	1,652	1,719	1,742	1,523	1,633	1,724
Total—Military Personnel	23,639	24,366	24,601	23,727	24,365	24,601	23,246	24,081	24,428
Retired Military Personnel	4,392	5,151	5,688	4,442	5,151	5,688	4,390	5,145	5,685
Operation and Maintenance	22,148	24,156	26,044	21,731	24,151	26,044	21,069	23,306	24,917
Procurement	18,574	18,653	19,867	17,473	17,998	19,867	15,654	15,144	16,359
Research, Development Test & Evaluation	8,020	8,333	9,322	7,960	8,306	9,322	8,157	8,414	8,890
Military Construction	1,464	1,821	2,150	1,356	1,592	2,141	1,119	1,299	1,499
Family Housing	1,009	1,148	1,273	967	1,102	1,245	729	966	1,089
Civil Defense	82	82	86	83	82	86	74	83	87
Special Foreign Currency Program	3	3	3	3	3	3	4	7	7
Naval Petroleum Reserve	—	—	24	—	—	24	—	—	18
Revolving and Management Funds	—	—	—	—	—	—	−1,030	6	−273
Offsetting Receipts	—	—	—	−105	−160	−289	−105	−160	−289
Pay Increase/Retired Pay Reform	—	35	2,089	—	35	2,089	—	35	2,032
Volunteer Force Legislation	—	64	153	—	64	153	—	62	151
Trust Funds	—	—	—	8	7	7	−2	18	6
Intragovernmental Transactions	—	—	—	−8	−6	−6	−8	−6	−6
Total—Military Functions	79,332	83,811	91,300	77,638	82,690	90,974	73,297	78,400	84,600
Military Assistance									
Military Assistance—General Accounts	1,120	3,295	1,279	951	3,325	1,240	954	1,392	1,511
MAP Offsetting Receipts—Fed. Funds	—	—	—	−90	−131	−161	−90	−131	−161
MAP Trust Funds	—	—	—	3,635	3,659	4,096	1,396	2,454	3,100
MAP Offsetting Receipts—Trust Funds	—	—	—	−1,730	−2,615	−3,250	−1,730	−2,615	−3,250
Total—Military Assistance	1,120	3,295	1,279	2,766	4,238	1,925	531	1,100	1,200
Grand Total—Department of Defense	80,452	87,105	92,579	80,404	86,928	92,899	73,828	79,500	85,800
Summary by Component									
Department of the Army	21,656	22,067	22,901	21,048	21,638	22,854	20,185	21,262	21,426
Department of the Navy	25,425	27,547	28,985	25,097	27,170	28,760	22,470	24,241	26,213
Department of the Air Force	24,707	25,495	27,471	23,934	25,272	27,451	23,627	24,411	25,487
Defense Agencies/OSD	2,008	2,165	2,590	2,012	2,118	2,584	1,771	2,133	2,364
Defense-wide	5,454	6,356	7,024	5,463	6,311	6,996	5,169	6,172	6,841
Civil Defense	82	82	86	83	82	86	74	83	87
Pay Increase/Retired Pay Reform	—	35	2,089	—	35	2,089	—	35	2,032
Volunteer Force Legislation	—	64	153	—	64	153	—	62	151
Military Assistance	1,120	3,295	1,279	2,766	4,238	1,925	531	1,100	1,200
Total—Department of Defense	80,452	87,105	92,579	80,404	86,928	92,899	73,828	79,500	85,800

OASD (Comptroller)

Effective in FY 1975

New Funding Policy Established for Test & Evaluation Activities

Will Charge Users for Direct Costs

In FY 1975, 18 major DOD test and evaluation support activities will start charging users for direct costs (any cost that can, with reasonable effort, be identified as directly applying to a user program). Users, such as DOD system program managers, will pay more than they have been paying at some test installations and less at others. In the past, users at some test support activities were not only charged direct costs but also allocated indirect costs; at others, users were not even charged direct costs.

Changes necessary for conversion to the new policy will affect many DOD program managers and will likely result in a new way of life for managers at some test and evaluation activities. Any organization requesting test and evaluation work will have to adjust its programs and practices to deal with the test support activities. Budget officials and program and support managers must clearly comprehend the new policy to understand and be able to analyze financial estimates and reports.

Need for Improvement

The Blue Ribbon Defense Panel, in its report of July 1, 1970,[1] emphasized the need for better test and evaluation management and cited the need for a major DOD-wide study of the Test and Evaluation Facility Base. The study was completed in August 1971 and, as a result of its findings, the Test and Evaluation Facility Base was established, consisting of 26 activities with a combined annual budget of well over $1 billion.

by John W. Cooley **and** **James W. Saylor**
Directorate for Accounting Policy
OASD (Comptroller)

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[1] *Report to The President and the Secretary of Defense on the Department of Defense by the Blue Ribbon Defense Panel, July 1, 1970, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; price, $2.25; order number D 1.2/B62/970.*

While the Test and Evaluation Facility Base study did not cover funding policy, the study group did find that, on occasion, variations in funding practices inhibited the choice and use of the best facilities for individual tests. This finding led to a comprehensive study of funding policies at the 26 activities. After an in-depth review, including on-site analysis, the Funding Policy Study Group, in April 1972, recommended institutional funding for indirect costs and user funding for direct costs (excluding military labor) on a uniform basis at all 26 activities. In January 1973, the Deputy Secretary of Defense directed implementattion of this funding policy to become effective at the beginning of FY 1975 at 19 (later adjusted to 18) of the 26 activities covered by the study. The test and evaluation facilities where the new funding policy will apply are listed in Figure 1.

The eight activities in the Test and Evaluation Facility Base, at which the new policy was not made mandatory, are smaller facilities engaged almost exclusively in supporting their parent military services. With a few exceptions, the institutional funds to finance indirect costs for all 26 activities will be provided under a single, composite program element for each military service.

Cause of Unfair Competition

While each of the major test and evaluation support facilities is unique, some overlapping capability does exist for certain routine jobs. Actually, direct competition exists only for a small portion of test and evaluation work. There is competition, however, for test support work assignments in some limited circumstances extending even beyond the Defense Department. Competition exists not only for jobs within existing capability where overlap is minimized, but also for major new programs requiring more sophisticated instruments that provide

Test and Evaluation Support Activities
Selected To Implement Uniform Funding Policy

Army

Aberdeen Proving Ground, Md. 21005

Dugway Proving Ground, Utah 84022

Electronics Proving Ground
Ft. Huachuca, Ariz. 85613

Kwajalein Missile Range
Marshall Islands, FPO San Francisco 96555

White Sands Missile Range, N.M. 88002

Yuma Proving Ground, Ariz. 85365

Navy

Naval Aerospace Recovery Facility
El Centro, Calif. 92243

Naval Air Propulsion Test Center
Trenton, N.J. 08628

Naval Air Test Center
Patuxent, Md. 20670

Naval Weapons Center
China Lake, Calif. 93555

Pacific Missile Range
Pt. Mugu, Calif. 93043

Air Force

Air Force Eastern Test Range
Patrick AFB, Fla. 32925

Air Force Flight Test Center
Edwards AFB, Calif. 93523

Air Force Special Weapons Center
Kirtland AFB, N.M. 87117

Armament Development and Test Center
Eglin AFB, Fla. 32542

Arnold Engineering Development Center
Arnold Air Force Station, Tenn. 37389

Space and Missile Test Center
Vandenberg AFB, Calif. 93437

Tactical Fighter Weapons Center
(Continental Operations Range)
Nellis AFB, Nev. 89110

Figure 1

justification for extending or upgrading capability. Healthy competition can be beneficial but the lack of uniformity in funding practices distorts cost comparisons between projects, causes inflexibility in the choice of support facilities for specific tests, tends to inhibit joint military service and interservice use of support activities and can result in misassignment of work.

Conceptually, the DOD approach has been to *either* provide funds to fully finance a support organization, with no dependence on users for financing, *or* to make the support organization totally dependent on users for financing both direct and indirect costs. A clean application either way permits simplicity of operation and enhances overall discipline based on traditional internal controls. In practice, there has been some erosion of both institutional funding and user funding. Due to budget pressures and other factors, institutionally funded organizations have sought and obtained reimbursement from users, and user funded organizations have found indirect ways to obtain institutional financial support.

Thus there have been wide variations in funding practices at DOD test and evaluation support activities, both within and among the military services. This stems from a combination of differences in military service management philosophy, organizational relationships, tradition, type of support provided, competitive influences and other factors. Most of the Army and Navy support activities have obtained reimbursement from users for nearly all costs, including applied overhead. Others, including most of the Air Force activities and the larger places, known as national ranges, have provided support to users substantially without charge. Some support activities have charged different portions of the actual cost to different users, even within DOD, depending on the customer and the appropriation used to finance the work. One objective of the new funding policy is to achieve a reasonable degree of uniformity in funding practices among the selected test and evaluation support activities where it will be applied.

Different Points of View

The managers of support activities generally prefer institutional funding, but not all of them. Those who have learned to operate successfully under a user funding system usually prefer that system. But they do not like unfair competition and resent losing work to organizations that do not charge users. Most program managers have preferred to include testing funds in their own budgets. Some top echelon officials suggest that it is easier to justify funds to finance a specific project than to finance an overhead activity.

Managers at most of the larger test and evaluation support facilities now under institutional funding maintain they could not operate effectively under a system of *full* user funding. They contend their costs do not vary with workload; that user funding discourages testing; that reliance on customer funds could compromise independence; that user funding creates administrative difficulties; that they cannot predict their workload very well; that last minute cancellations and delays which characterize the test and evaluation business could cause severe financial problems; and that user funding would cause erratic budget fluctuations not conducive to maintenance of an adequate test and evaluation base. In short, the larger test and evaluation support activities currently operating under institutional funding have been reluctant to support the concept of full user funding, and are uneasy about depending on users to finance their operating expense.

The advocates of user funding point out that such a system has been working satisfactorily at several of the activities where the new funding policy will be applied, and has been for several years. They maintain that user funding encourages cost consciousness; greatly improves communications between support activities and their customers; supports the program management concepts now practiced by DOD; highlights overcapacity; and asks the right questions of the right people at the right time. They suggest, also, that under institutional funding, high priority projects tend to unnecessarily monopolize test facilities. Some of the activities already operating under an industrial fund with full user funding consider the new funding policy as a major step backward in the evolution of financial management systems.

Some program managers maintain that, without testing funds, they have responsibility without matching authority; that they are and should remain primarily responsible for the quality of their product; that they should be able to balance resources between testing and other aspects of their programs; that they get better reaction to requirements if they have the funds; and that institutionally funded activities tend to be overly independent and insensitive to time schedules. Most program managers, however, do not like to see increases in their budgets, even when the increase represents nothing more than a cost transfer for services previously provided without reimbursement.

Basic Issues

In overall efforts to improve financial systems within DOD during the past several years, a major issue has been the determination of who pays for what. This issue has a tendency to cause people to choose sides. A first reaction might be what difference does it make how the funds are budgeted and distributed—the overall cost to the Government is the same. In practice, the difference is substantial and the overall cost to the Government is not necessarily the same. Funding patterns involve proprietary instincts and influence motivation. Control of funds is an important source of power and security affecting who has authority in the organization and the span over which trade-off decisions are easily made.

User funding offers clear-cut advantages for some types of support activities where buyer and seller relationships can be established and where other conditions are favorable. Among requirements for successful application of user funding for services are an adequate cost accounting system, reasonably reliable aggregate workload estimates, and flexibility to permit decentralized management decisions. Under user funding, operating level managers are given broad latitude to make decisions under conditions oriented, by design, toward rewarding good management and exposing poor management. Movement toward centralization can weaken or destroy many advantages of user funding, thus leaving the administrative procedures to support user funding without offsetting benefits. The Defense Department has attempted to exploit the advantages of user funding to the maximum extent feasible.

Revolving Funds Help

User funding systems require a method of financing goods and services from the time they are purchased and paid for by the support organization until reimbursement is received from the user. Working capital funds established for this purpose include stock funds to finance inventories and industrial funds to finance work-in-process at service and "industrial" type activities, including organizations performing research, development, test and evaluation (RDT &E). Use of working capital funds is authorized only when a prescribed set of procedures is employed to assure adequate discipline and internal controls. Thus, the terms "stock fund" and "industrial fund" have become generally associated by DOD managers with the overall management control system regulating their use.

Use of stock funds and industrial funds within the Department of Defense during the past 20 years has paid big dividends. In 1956, W. J. McNeil, then the DOD Comptroller, stated, ". . . every place where we have established a revolving fund, we have made a real profit for Uncle Sam." For several years, the overall DOD policy has been to encourage and promote user funding through use of revolving funds for service and support activities, including RDT &E, to the extent feasible. The industrial fund is sometimes called a "service fund" when applied at a research and development activity.

Disciplined Controls Essential

User funding for either all or part of the cost at RDT&E activities is now possible without a separate industrial fund cash account. By using a stock fund to finance inventories, the largest fund source can be used to pay for operating expenses, and all of the costs can be charged to the users before the books are closed at the end of the month. This system is currently used by several research and development activities and will be used by most of the organizations operating under the new test and evaluation funding policy.

The new funding policy for the 26 activities of the Test and Evaluation Base represents a compromise between institutional funding and user funding. It was chosen on the basis that uniformity in funding policy is both desirable and feasible, and neither full user funding nor full institutional funding is feasible on a uniform basis for all of the activities.

The compromise is in the amount of user

funding, not in the control of funds. The new funding policy requires the same kinds of disciplined controls that are prerequisites for application of an industrial fund. Each activity must use the same accounting procedures in identifying direct costs of all jobs performed for any outside party. Characteristics of the operating level system required by each support activity for success under the new policy are:

- Reasonably reliable aggregate workload estimates.
- Effective communication with users.
- Cost estimates by job.
- Accurate and timely reports of actual direct costs by jobs related to time-phased job estimates.
- Flexibility and fast reaction for adjustments in fund authorizations.

The Job Ahead

The FY 1975 budget requests from users were developed, submitted and reviewed based on the new funding policy. Fund requests have been adjusted between user programs and institutional programs. Job order cost accounting systems have been installed at all but one of the test and evaluation activities where the new funding policy will apply. A mock implementation of the system is being conducted throughout DOD during FY 1974 and the mechanics of the system are ready for live operation.

The biggest problem is that initial estimates of direct costs did not produce the anticipated degree of uniformity because there was a tendency to understate direct costs in initial budget estimates. The budgeted direct costs have been as low as 8 percent of total funded operating expenses. If initial estimates of direct costs were below the established 25 percent minimum level of direct costs to total funded operating expenses, the military services were directed to develop new budgets before apportionment.

For many years, direct costs have been segregated from overhead as a cost accounting device in both Government and industry. Historically, this distinction has merely aided distribution of total costs to products and services. Since distinction between direct and indirect costs normally has little impact on certified financial statements, the accounting profession has not developed and enforced rigid cost accounting standards covering the definition of direct costs. The distinction between direct and indirect costs, therefore, is not a normal basis for segregation of funding. Separation of "direct costs" from overhead has not been required to withstand pressures that will apply when the differentiation under the new policy affects fund availability. Operating level managers may attempt to exert influence on the classification of costs between direct and indirect to serve their own best interests. If the new funding policy is to work satisfactorily, the definition must be objectively applied. Deliberate manipulation in application of the definition for self-serving objectives must be avoided.

Because determination of direct costs is not an ideal basis for segregation of funding from the point of view of an accounting system, close monitorship and added internal controls will be required in the early stages of implementation of the new policy. This will include scrutiny in budget reviews and internal audits. The system must be enforced so funding availability will be adjusted based on cost accounting and prevent natural pressures from adjusting cost accounting based on fund availability. After the new funding policy is fully operative, pressures from the users to minimize direct costs, and budgetary pressures through command channels on institutional funds, should tend to keep the system functioning reasonably well. ☐

Acquisition Management Needs Realistic Forecasting To Close the Confidence Gap

The U.S. General Accounting Office (GAO) is an independent, nonpolitical agency in the legislative branch, often described as the overseeing arm of the Congress. Its job is to tell Congress—and the public—how well the executive agencies are carrying out their responsibilities, just as it is the responsibility of the test pilot to tell the designers and engineers how well their equipment performs in relation to mission requirements.

GAO also has the responsibility to recommend ways for improving proposed and ongoing Federal programs and to make known the results of its studies before irrevocable decisions are reached. These functions are especially important when there are strong pressures for initiating new approaches or infusing more money into programs that have not demonstrated their worth.

In recent years GAO, responding to the needs of the Congress, has placed major emphasis on evaluating defense systems program performance. Almost one-third of GAO's work involves program evaluation and, more than ever before, Congressmen are using GAO reports which contain information on virtually the whole range of Federal Government operations.

Almost every subject or activity, such as activities of doctors in the Medicare and Medicaid programs, management of Federal inspection programs in meat-packing plants, and administration of the laws governing campaign receipts and expenditures for presidential candidates, is examined by GAO auditors sooner or later. In response to increased interest and important concerns in Congress, the areas in which industry and the military services are most directly concerned, *e.g.*, advanced technology aircraft and space programs, have been high on GAO's agenda. To illustrate, GAO has reported to Congress on:

- Lowering costs and increasing pilot proficiency through greater use of flight simulators in military pilot training.
- Reduced requirements for modular electronic equipment for aircraft.
- Need for improved controls for identifying and correcting safety defects on light aircraft.
- Need to develop in-flight escape systems for helicopters to prevent fatalities.
- Cost estimates for the space shuttle and two alternate programs.

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U.S. General Accounting Office

Opinions expressed herein are those of the author and not necessarily those of the Department of Defense

- Growth and use of airports in the Washington area.

The need to prepare these kinds of reports for Congress has made it necessary for GAO to develop competence in many new disciplines related to engineering.

Community of Interest

For example, many of the new requirements being placed on GAO auditors by Congress are similar in numerous ways to the requirements test pilots have had to meet in recent years. The experimental test pilot provides judgments, derived from his flight tests, to engineers and designers; he forms a vital part in the systematic flow of measurements of flight performance compared to projections and expectations; and he participates actively in the analysis of performance information which influences future decisions.

The test pilot is, therefore, in the auditing business in a very real sense. He knows how to "wring out" an aircraft. In a somewhat different way, GAO auditors are learning to extract the essential information for a realistic evaluation on how an acquisition program is planned, carried forward and fulfilled.

In both professions, we seek accurate information and verifications, look for dangers of the system failures and make evaluations. The test pilot tries to bring out information that will provide the right guidance for making decisions at critical points in the development of a new weapon system. In the same way, GAO auditors try to bring information to the surface concerning major systems acquisitions that facilitate similar critical decisions.

One aspect of the problem of weapon system acquisition is the cost and performance credibility gap—the differences between estimated and actual performance and cost. There are some things that have to be done by GAO auditors, test pilots and DOD program managers to help close this gap.

Public and Congressional Frustration

The rising concern of the Congress and the public about the increasing costs of new defense weapons is certainly not news. The patience of the public and the Congress has been worn thin by repeated experiences with contractor and Defense Department cost forecasts for new weapons that are unrealistic, and the promises of performance miracles by new weapons that later proved unattainable.

To put all this more bluntly—and this point needs to be fully recognized—more and more members of Congress are increasingly skeptical of the testimony of DOD officials on future cost and system performance. The public, in turn, has become skeptical of not only the Defense Department but also the Congress on defense issues. When enormous expenditures and national security are involved, the subject takes on major significance.

However, GAO representatives who work closely with congressional committees, know well that if Congress develops confidence in proposals and estimates of cost and performance, it will support new programs. The key word is "confidence" and it must be restored. This can occur only through a demonstration of better cost estimates and better performance.

Cost and Performance Trade-Offs Critical

We all know the most significant cause of increasing costs has been the demand for more highly sophisticated, multi-purpose weapons which has forced cost curves to climb almost vertically. A comparison of the latest generation of weapon systems, for example, shows that the cost of a successor system is between two and six times greater than that of its predecessor.

As defense systems become more sophisticated, the management problems become more complicated. Technological problems frequently lead to rapidly accelerating costs and/or reduced operational capabilities. Cost and performance trade-offs often become critical. The tendency has been to reduce the quantities procured as costs go up which leads to concern on the part of the Congress and the military planners that the level of defense may not be adequate.

In the defense weapon systems development area, there must be DOD program managers and contractors who are more than just program advocates. They must be willing to slow down a program until problems are solved or even terminate it if problems cannot be solved. In other words, ways must be found to stop programs which turn out not to make sense.

Whatever the past mistakes of the DOD program manager and the prime contractor, new and better ways should be found to reward them when their work is done well. There should be better rewards for good contract and program management as well as penalties for failures to live up to commitments.

Beneficial Management Practices

GAO auditors recently completed a study of 11 major weapon systems acquisitions to identify management practices which consistently proved beneficial, as well as those which were detrimental. The idea was to aid in improving future acquisitions on the basis of lessons learned.

Here are some of the benefits, as GAO sees them, which flow from good management practices by the contractor and by the Government, or by the contractor and the Government acting together:

- Technological development risks are kept to a minimum to greatly increase the chances of meeting program objectives.
- Early and accurate assessment of the extent of a program's technical challenge is vital. Uncertainties and unknowns are recognized at the start and schedules and costs planned accordingly.
- Determining that a program's technology is *in hand* before a major commitment of program resources.
- Utmost use made of proven components.
- Systems designed for potential growth.
- Flexibility for trade-offs is maintained.
- Goals are most readily and satisfactorily achieved when the Government and the prime contractor work together as a team.
- A major factor in the program's success is the contractor attitude of total commitment to a program from top management down.
- Following the advice of Albert Einstein, "everything should be as simple as it can be, but no simpler."

Test Pilots in Key Positions

No professionals in the United States understand better the need to improve the system than those in the aerospace industry and the military services. Recently a member of the industry described what is required of a competent test pilot. Although it is not news, it is worth emphasizing.

More than ever before, he said, the test pilot has to provide designers and managers with better insight into the combat usefulness of the equipment he tests. He must not only understand the entire data-gathering system but also be sensitive to the user environment, the limitations of man in the operational environment, and the probable counteractions of a resourceful enemy. In reporting to management, he not only must serve as an engineer and test pilot but must *act* like a manager himself.

Test pilots and managers are on the front line of the current effort to restore the public's confidence in the defense weapons for which it is asked to pay. They must exhibit something the public understands better than technical expertise, *i.e.*, courage and frankness. Test pilots must bring to the surface information that program managers need to make decisions which will yield weapon systems that will work effectively in the operational environment.

The survival of a new defense system, and the contractor that develops and produces it, may well depend on the man who frequently is in the best position to visualize or identify problems—the test pilot. Success may rest on his courage to tell management what he thinks must be done, however controversial this information may appear.

It is generally suggested the chief test pilot of a company should have the ear of his president, directly and whenever he needs it, to get jobs done right. For the same reason, the internal auditor, checking activities of his "company," must have the ear of his "company president"—the top man in his Government agency—if his information and advice is to be effective. Top management must provide a channel for such communication.

A GAO report[1] on cost growth in major weapon systems, published in March 1973, provided the basis for two days of later testimony before the House Armed Services Committee.[2] There is no better consolidation of GAO's views toward the many problems besetting our weapon systems development programs than this testimony. It encompasses not only GAO's views but also those of other groups who have done special work in this area, including the Commission on Government Procurement.

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[1] *GAO Report No. B 16058, "Cost Growth in Major Weapons Systems," March 26, 1973.*

[2] *Report No. 93383 of the Committee of the Armed Forces, House of Representatives, July 18, 1973.*

Signs of Progress

In the cost growth report there is a summary of GAO's conclusions and recommendations reflecting encouraging signs as well as areas of continued concern. Here are some of the encouraging signs:

- There is a return to prototyping of hardware and to the "fly-before-buy" concept.
- Most recently the design to a cost approach, aimed at avoiding goldplating and controlling sophistication in hardware, has begun to be applied on major new systems.
- The Defense Department has assigned and trained more specialists to strengthen the Government's in-house capability for making realistic cost estimates.
- Defense teams now conduct should-cost reviews at contractor plants to provide better visibility over the contractor's efforts to meet cost, schedule and performance objectives.

Another good sign is the establishment of the Defense System Acquisition Review Council. Its members, responsible senior DOD officials, evaluate major program acquisitions at key decision points to make sure that there is justification for continuing the development of a system. However, this process will yield no better decisions than the information and advice in the test data, including data supplied by the experimental test pilot.

In finding a way to better management of weapon systems procurements and similar large undertakings, we in this country still have a lot to learn. The current report of the House Committee on the Armed Services on the 1974 military procurement authorization bill[3] aptly summarizes some of these points. The report states that:

> "There are no easy panaceas, but rather a requirement for a lot of hard work at all levels in the defense business."

Perhaps even more important, the Committee also includes this statement:

> "The Committee would call attention to the recommendation in the Comptroller General's report that the Congress get involved in weapons decisions at an earlier point in the decisionmaking process before executive branch decisions are solidified. The Committee believes that this is central to effective control by the Congress. . . .
>
> "The Committee calls to the attention of the Defense Department officials, military and civilian, the part of the Comptroller General's report stressing the need for candor with the Congress about uncertainties in programs and the importance such candor will have in developing the necessary confidence in the Congress for support of defense programs."

Therefore, it is not managerial competence alone that is needed. What is needed even more is for all involved in systems acquisition to voluntarily accept higher standards of accountability for whatever their responsibilities may be. That responsibility, of course, involves us all. □

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[3] *Ibid.*

It takes two to speak the truth —one to speak, and another to hear. —Henry David Thoreau

One of a Kind Spacecraft Designed to a Cost

For more than a decade, the aerospace industry has grown and gained experience and knowledge in dealing with the environment of space. Many early uncertainties have been overcome. Unmanned spacecraft have been launched and supported in space so their useful life is years instead of days. Man's ability to function in space has been demonstrated and his length of time in space has been increased from hours to several weeks. Problems associated with planetary entry and earth's re-entry have been solved. Early reliability and redundancy concerns have been overcome. Engines have been restarted in space and on the moon. Very sophisticated sensor systems were developed and have performed in space. In short, the industry has moved towards maturity in the space environment in a compressed time period.

by Edward Offenhartz
ELMS Program Manager
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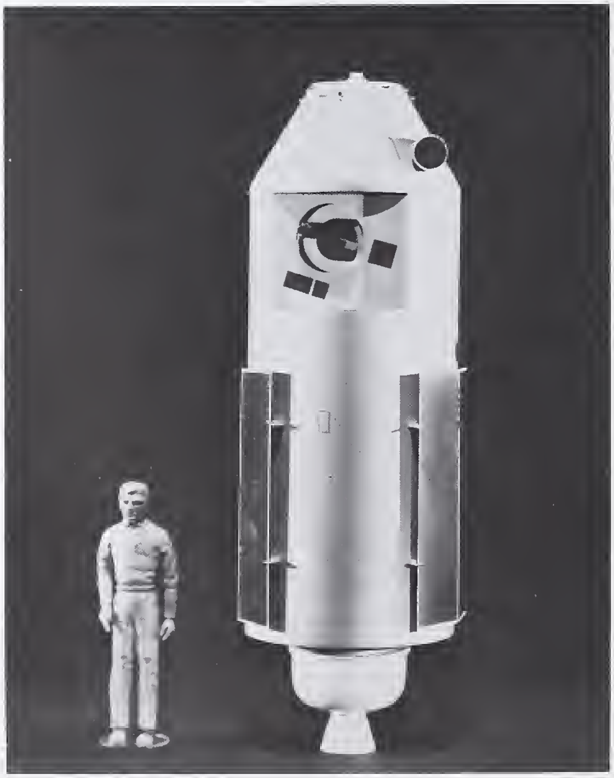
Opinions expressed herein are those of the author and not necessarily those of the Department of Defense



Scale model of the Earth Limb Measurement Satellite.

ELMS

Grumman Aerospace Corp., Bethpage, N.Y., was awarded a $12.9 million contract in September 1973 for the construction of two Earth Limb Measurement Satellites (ELMS).

The spacecraft will carry sensors to determine the nature of radiation emanating from the earth's upper atmosphere. Information from the two 20-day missions, designed to meet military requirements, will also be of use to the general scientific community.

The design to a cost contract places major emphasis on cost with minor variations permitted in performance and/or schedule to stay within the established cost framework.

With this succesful background and expanded base of knowledge and experience, it is appropriate to seek ways to apply the design to a cost concept to spacecraft development. In the past, DOD and its contractors have tended to separate performance requirements from the cost of their achievement. In the design to a cost approach, an effort to restore the balance between performance and cost is required. Its objective is to attain operational systems consistent with performance and quality requirements and to realize better value for the DOD dollars spent. The contractor and DOD must work together to develop and produce affordable defense systems within changing priorities and stringent budgets.

This article will examine the application of the design to a cost concept to a spacecraft system program in which development represented the largest portion of the acquisition cost. This contrasts with most design to a cost efforts which usually involve significant production quantities, hence requiring consideration of potential product cost savings as well as development and prototype unit cost savings. The objective of the program is to achieve maximum performance for a fixed development cost.

Ground Rules

How was the cost objective achieved in response to the procurement package, its requirements and restraints? A typical spacecraft cost distribution and breakout is shown in Figure 1. The split indicates that approximately 60 percent of the effort was accomplished in-house by the prime contractor, with 40 percent of the associated elements procured from subcontractors. This split varies, however, according to program requirements and can swing in a 60:40 reversal between the two depending upon the design and its implementation. Essentially, the ability to achieve a design to a cost objective rests upon understanding the mission and system requirements, proper allocation of available funds and effective management of cost starting with the conceptual design. To achieve the correct balance between performance, schedule, risk and cost, the following guidelines were established by DOD and prime contractor program management:

- Use flight hardware previously qualified to the specified environment.
- Meet specified testing requirements at the highest level of assembly.

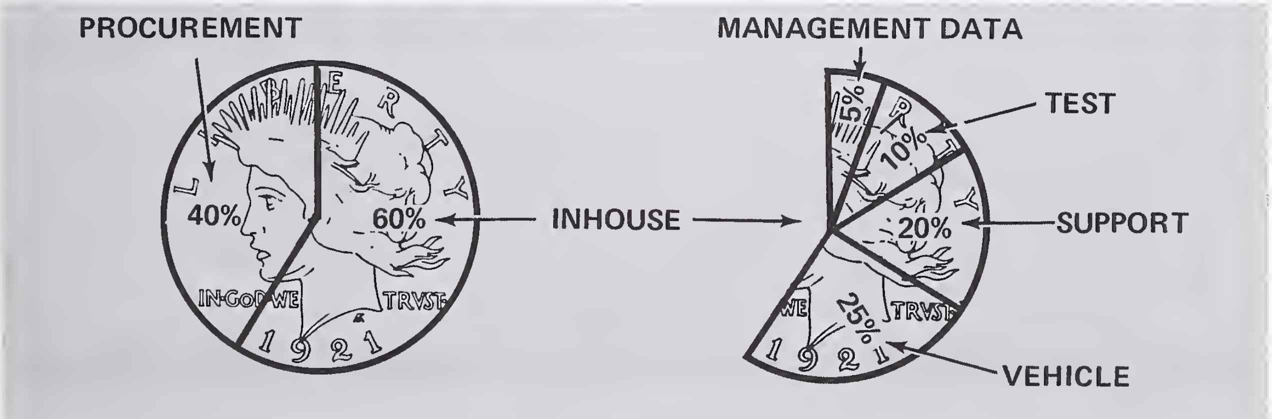


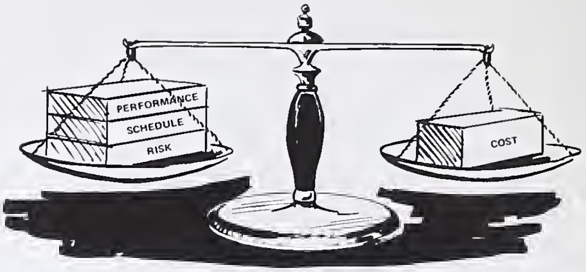
Figure 1

- Use hardware similarity or analysis to reduce test requirements.
- Refurbish hardware after qualification test and recertify for flight use.
- Provide redundancy as required for mission success.
- Incorporate maintainability into the design.
- Minimize risk to DOD and to the contractors.

Approach

Grumman's system development approach uses a disciplined multiskilled team to translate customer mission and functional requirements into configuration definitions and subsequent detailed designs within program management guidelines. The guidelines are simple: The end item must meet, or exceed, the required performance at target cost. The team process stimulates evaluation of alternative competing configurations and designs. Decisions are based upon trades between cost and performance parameters within achievable schedules at acceptable risk. The object of these iterations is to achieve a balanced program.

The program team for the spacecraft development was carefully chosen based upon past performance in cost awareness and control. Design targets were established by program management and broadly defined to the team responsibility centers; *i.e.*, engineering, test, fabrication and assembly. These initial targets were, in fact, functional breakdowns of the cost distribution. The multidisciplined team was briefed on the balanced approach and collocated to reduce reaction time, ease communications and encourage the cross-pollinization of innovative ideas. The environment was conducive to alternate approaches and all participants were encouraged to seek new ways to apply the design to a cost concept.

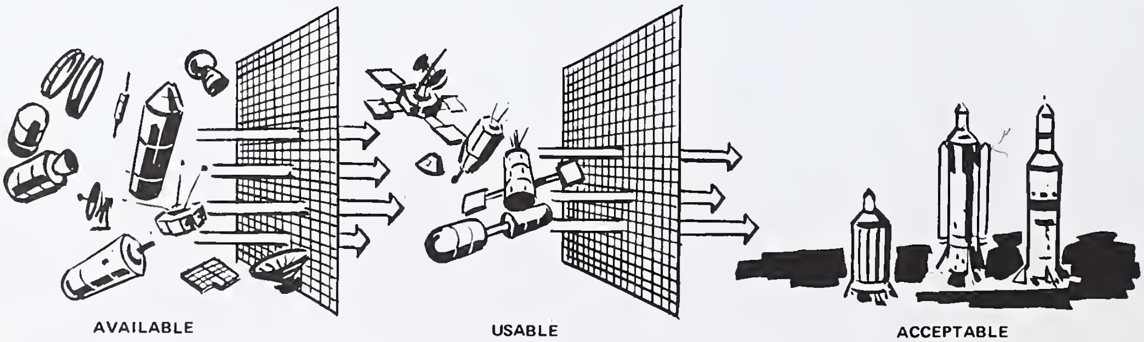


Challenge

Developing a credible ceiling which guarantees performance with reasonable profit for the contractor was the competitive challenge. To meet this challenge, the program team had to implement a plan of attack. The systems and design people needed access to technical and cost data at the start. They had to know the cost of designing, testing and producing special spacecraft equipment, subsystems and support and test equipment.

The emphasis on cost generated requirements for supporting information consistent with the new approach. Spacecraft parametric cost models were updated. Models based upon experience gained from earlier technology with different performance emphasis were not applicable. Improved methods for determining cost per pound, cost per part, watts per pound, etc., were developed. Industrial rules of thumb were used for quick-look judgments as, for example, the solar panel area in terms of cost per watt.

The existing inventories of materials, components and parts provided information from which first-cut system and subsystem decisions were iterated to achieve the allocated cost targets. Items required, but not in the inventory, were designed to achieve a balance between performance and risk within cost allocations.



Producibility at low cost required using standard processes and nonexotic materials. The result of the first-cut system was the evolution of a baseline considered to meet the cost, performance, schedule and risk requirements.

Action at the Boards

Design to a cost became a team challenge. Engineers responded to this challenge of cost restraint when management indicated the importance of cost and performance balance. Acceptability and necessity were driven home by management reviews at the drafting boards with free give and take discussions on performance, risk, cost and schedule. Action was centered at the work place, not in a remote sterile conference room. Mission and subsystem concepts were iterated. Communication was open and informal. Problems were surfaced and resolved. Control and accountability were maintained without excessive paperwork. Work took place in parallel as series effort was discouraged. The activist multidisciplined team was "turned on" by the process.

The suggested management performance and cost targets were defined and then challenged by the team responsibility centers within 72 hours. The challenge was based upon the allocation mix and the existing design concept. For example, many underdeveloped, to be developed and unqualified subsystems found their way into the initial design. Test requirements and time spans were excessive when compared to budget allocation. Government test facilities were not considered. Drawing releases were required too early in the program forcing an unnecessary and inefficient front manpower loading. The design concept was not consistent with the procurement budget, etc.

After thorough evaluation of alternatives, the team participated in modification of the initial design concept to achieve improved performance at the same or less cost. A program master schedule was developed which met all customer requirements and defined element activities in a cost effective manner. Interplay between the scheduled activities and supportive manpower buildup resulted in an orderly program definition.

Detailed task descriptions defined the work to be done, the time phasing and input and output required to eliminate duplication and nonessential activity. The tasks were cost estimated using in-house standards developed for similar activities. The spacecraft was broken into modules to allow parallel assembly. Quality and maintainability were designed into the spacecraft. Reliability evaluation dictated equipment performance specifications and levels of redundancy.

Suppliers

A prime contractor, of necessity, develops a viable subsystem and component supplier base, capable of responding to contract performance requirements in a competitive environment. Suppliers must become part of the design to a cost approach at program inception. With approximately 40 to 60 percent of the prime contractor's effort in supplier hands, it is not productive to keep their inputs in a holding pattern. A competitive environment is created because design to a cost challenges suppliers when cost and performance are of real concern.

On the spacecraft development program, potential suppliers were solicited by bid invitation which contained streamlined specifications screened to eliminate desirable but not required effort. Evaluation of acquisition risk was required to implement the design to a cost approach. For flight proven equipment, acquisition risk is minimal. For new designs requiring extensive development, there is maximum acquisition risk.

Technical, cost and schedule risk criteria were established by the prime contractor against which the proposed activities of the suppliers were measured and a composite risk determined. Technical risk includes consideration of the status of the applicable specifications, equipment suitability and flexibility, safety margins, etc. The ability of the seller to meet size, weight, performance and other factors was evaluated. Schedule risk criteria includes consideration of quotation type (cost plus fixed fee, cost plus incentive fee, etc.), specifications and cost control history.

The results of the evaluation compared against the acquisition risk criteria were used for equipment selection, contract type selection and as an indicator for areas requiring early and continuous prime contractor visibility. Design use of pre-qualified hardware was helpful but acquisition risk indicated that management attention was needed. Team members visited suppliers of mission-critical risk items to assure that proposed development hardware could be produced as priced. The design to a cost approach "went on the road" for exploration with potential suppliers.

Budget Control

Budgets were allocated to the team responsibility centers for their effort. Influence factors to limit the cost that their output imposed on the next in line tasks were assigned. The designer, for example, could change his approach provided he kept within his budget and the fabrication or procurement budget was not increased because of a desirable but unnecessary change. Collocation made this easier to accomplish. The tasks could be re-estimated to evaluate the cost impact of change while still in the conceptual phase. When absolutely required, management reassigned budgets for justifiable change.

The design to a cost approach required flexibility and innovation within the bounds of control and discipline. Management control could not wait for the report of trouble; problems had to be anticipated and corrective action implemented. Initial targets were set with allowance for growth but control was exercised to keep the growth within the set limits.

Target costs originally allocated were altered to meet the changing needs of the operating functions. Detailed estimates from the lowest working level, coupled with top management participation as concepts evolved, narrowed the honest differences to be expected from the various vantage points of the decision makers. Independent parametric analysis and estimating techniques converged. After evaluation of 20 different systems concepts and 50 different subsystem variations, confidence in the ability to do the job within the cost ceiling was established internally. The supportive data base was creditable. The team was convinced that the combination of in-house estimates and those of the suppliers defined a realistic, achievable cost base. The one of a kind unmanned spacecraft could be designed, developed, tested, launched and supported at a price consistent with DOD requirements.

Customer Influence

If the innovative dynamic environment of the design to a cost concept is to survive through the procurement cycle, then the customer must also adopt the spirit. The DOD program manager must participate in the evolution of the design and have the flexibility to re-examine performance requirements in light of their cost impact. The customer and contractor must work together to achieve the design to a cost objective.

Presently, application of the design to a cost concept to defense systems programs has inherent anomolies. Although technical requirements now reflect the difference between desirable and acceptable, there is still a tendency to over-specify requirements. The contractor is left with few options. The contractual form needs to be re-examined. However, the design to a cost objective can be met and, in time, both DOD and its contractors will find the flexibility of approach which yields affordable quality defense systems.

The lessons learned from the case study described herein are applicable to more complex production situations. Management must take an active participatory role to achieve a balance between performance, schedule and risk within the target cost and, along with the system design decision makers, force cost considerations in all phases of the acquisition process. ☐

Design to a Cost: A Sampling of Extent of Implementation

Emphasis on the application of the design to a cost concept was reinforced by Deputy Secretary of Defense William P. Clements in a letter on June 18, 1973, to the military departments directing that program managers be given the authority to make performance and schedule adjustments to achieve design to a cost goals on programs which would not reach Milestone III by August 31, 1973. As a result, several major systems acquisition contracts now contain requirements for application of design to a cost targets.

The Defense Product Engineering Services Office (DPESO), Office of the Assistant Secretary of Defense (Installations and Logistics), recently completed a sampling of seven prime contractors and two subcontractors to determine to what extent the techniques of design to a cost were being implemented on defense system development programs.

Data was collected in several areas considered fundamental to a design to a cost effort. The premise was that these areas would be evident to some degree if a conscientious effort to control production costs was being made by DOD program managers and the contractors.

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OASD (I&L)

The sampling was designed to obtain information in two categories:

- Design to a cost requirements expected to be found in the contractual agreements.
- Actions taken by contractors to respond to design to a cost requirements.

The key data related to design to a cost requirements contained in contracts which were reviewed is presented statistically in Figure 1; data on contractor response is presented in Figure 2 (see next page).

Two bits of data in Figure 1 that may not appear to have any bearing upon the design to a cost process are the escalation factor and the experience curve used to cover adjustments in quantity of items procured.

In the case of the escalation factor, it means considering the reality of changes in the economy—either up or down—in advance of change. The basis for such change, agreed upon in advance of the result, will eliminate major disagreement when adjustment of the design to a cost requirement is put into current environments.

Requirements Contained in Contracts

Contract Review	Yes	No
RFP Required Design to a Cost Response	4	5
Contract Contains:		
Design to a Cost Requirements	9	
Escalation Factor	3	6
Experience Curve to Cover Adjustment in Quantity	1	8*
Mean Time Between Failure Requirement	7	2
Mean Time to Repair Requirement	5	4**
Performance Requirements in Order of Precedence	2	7
Allocation of Significant Profit to Meet Design to a Cost	4	5
Profit in Production Based on Design to a Cost		9

*Includes two informal agreements between contracting officers and contractors.

** Not appropriate in two cases.

Figure 1

The use of experience curves is not an absolutely exact measure of cost adjustment when quantities change, but it is a very good indicator for such purposes. The use of such curves is expected to eliminate the disadvantage the buyer finds himself facing when a reduction in quantity results in a price adjustment.

Benefits to Contractors

Five of the nine companies were emphatic in their defense of the value of design to a cost benefits to defense systems programs. Some benefits indicated were:

- Availability of information early enough in the design cycle to do something about production cost.
- Visibility providing knowledge of product cost.
- Provision of a realistic basis for DOD and contractors to assess the cost impact of the work scope and a base line for change to some specifications.
- Promotion of cost consciousness among designers in determining trade-offs and changes in design approaches to accomplish contract requirements.

Contractor Reaction to Design to a Cost Requirement

Contract Review	Yes	No
Responsible Management Agent Identified for Design to a Cost Actions	8	1
Agent Reports to Program Manager	6	2*
Cost Model Constructed:		
Percent Budget Expended When Cost Model Constructed**		
0–6%	3	
7–12%	2	
105%	1	
Production Cost Targets Assigned to Design Groups	5	4
Estimating Support—Near Real Time Production Cost Estimate Feedback	5	4
Review Time Sequence—		
Weekly	2***	
Monthly	5	
Other		3
Review by Top Management	4	5
Written Procedure for Design to a Cost	3	6
Is Design to a Cost Proving Useful?	5	4

* One company had no identified agent.

** Three did not have models established.

*** One also reported monthly.

Figure 2

A contractual requirement is no guarantee of appropriate compliance. Reporting by the contractor to the buyer will not assure design to a cost application. All contractors included in the review were reporting data periodically in some form; however, only five out of nine companies were making meaningful design to a cost data available to the designers—the people who cast the die for production costs.

Estimated production cost visibility can be available very early in the validation or engineering development phase of a system development program. As indicated in Figure 2, five companies had such information available before 12 percent of the current budget was expended.

Competition for a large production contract did not guarantee that production costs would be considered during the design effort. Three large production contracts were being sought by six contractors (two on each item), yet only three of the contractors were really emphasizing the design to a cost requirements of their contracts. Two of these three were competing for the same contract.

There is no assurance that a design to a cost requirement placed on a prime contractor will be effective at the subcontractor level. One major design subcontractor was found planning to design a product and then tell the prime contractor what it would cost to produce it, even though his subcontract included a design to a cost requirement.

Positive Effects

In those programs where the buyer and seller program management were very much in agreement on their objectives, the results could be judged as favorable.

The DPESO review indicated that, in those instances where design to a cost application was positive, the following conditions existed:

- Production cost targets were assigned to the design groups.
- Cost models showing expected distribution of the functional costs existed.
- Professional cost estimators supported the design groups.
- Progress toward the design to a cost parameter was regularly reviewed by top management; *i.e.*, vice president, general manager or program managers.
- Engineering cost trade-offs for various design approaches were being accomplished to meet the performance parameters as well as the production costs.
- Buyer and seller program management were both very conscious of the design to a cost requirements and were exercising their management prerogatives to assure the best combination of performance and production costs was being realized.

Production cost visibility for management and the designer represents a fundamental criteria necessary to meet a design to a cost target. Based on prior DPESO experience, the lack of production cost visibility during design practically assures the cost target will not be met. This conclusion is based on the premise that management cannot manage something it cannot see. ☐

"Fine quality in a manufacturer is a corporate state of the mind. It must be the dominant factor in every decision made by any manufacturer—the dominant factor in the choice of material, in the supervision of craftsmanship, and above all, in the research, design and engineering."—*John Steinway.*

C/SCSC: Alive and Well

"Major, are you trying to tell us, one of the world's largest corporations, how to manage? If you want us to try this C/SCSC system on your program—and we think we've done pretty well without it for a long time—it'll cost you two and a half million dollars."

This response was typical of industry's reaction to the cost/schedule control systems criteria (C/SCSC), circa 1967, and to its Air Force predecessor, the cost/schedule planning and control system. A number of individuals within the Defense Department also had reservations about the concept.

Five years later, the corporation was visited again by the same officer and he found it had implemented C/SCSC across the board in the division concerned, on commercial as well as on defense projects. "What did it cost?" he inquired. "Well, a little less than a quarter of a million," a company spokesman acknowledged, "including our commercial programs."

This change in attitude toward C/SCSC is not unusual. The problem was that many people thought it was another system, a management veneer, that would be imposed with varying degrees of success and then scrapped.

What was not understood in those days is that C/SCSC is not a system. It is *criteria* or a set of standards that a contractor's management system, whatever it may be, must meet in undertaking development of a major defense program. "Criteria" is the key word in C/SCSC.

Essentially what C/SCSC does

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Defense Systems Management School

is ensure that data provided by a contractor, such as his monthly cost performance report, is accurate and timely. Cost and schedule deviations can then be traced to their source and action taken. But C/SCSC, alone, provides no project operations data nor does it require that any be collected.

There are some 35 of these criteria in the C/SCSC Joint Implementation Guide.[1] They define the standards a contractor's management system must meet regarding organization, planning and budgeting, accounting, analysis, revision and access to data.

During the past two years, C/SCSC has been widely implemented by defense contractors and many companies have also applied their DOD-approved systems to commercial and industrial projects because of the improved visibility provided. Others have requested validation reviews even though they did not have contractual requirements for C/SCSC-compliant systems. There was adamant opposition to the criteria in the early days, however; and there are still pockets of resistance to the C/SCSC "system."

Adopting the Criteria

Recognizing a need for better visibility of program status and for more reliable data, the Air Force in the latter 1960's was determined to "go" with the criteria approach. Industry, thinking it was another here-today, gone-tomorrow management cult, was equally determined to resist. This impasse lasted for two or three years.

Finally, in 1969, one contractor realized, "These guys aren't going to go away." The management of one of his divisions pushed for compliance with the criteria, made the relatively few changes required and, in April of that year, the division's management control system was validated as complying with C/SCSC.

This caused a virtual stampede as others recognized that C/SCSC was here to stay. The problem then was to ensure that a contractor was, in fact, using his own management system, rather than trying to duplicate the first contractor's validated system. Surprising to most contractors since that time has been the fact that a good existing system is generally 90-percent satisfactory insofar as the criteria are concerned.

By January 1974, the Air Force had 48 contractor validations, almost half being conducted by teams consisting of representatives of the three military services. Another six contractor demonstrations were in process or planned. The Army has accepted 24 systems, with 31 in process and 16 more planned; and the Navy, starting after the other two military services but developing an aggressive program, has 25 C/SCSC applications accepted, in process or planned.

From the number of validations and planned demonstrations, it is obvious that a major part of the defense contracting community, prime and subcontractors, have been covered by the criteria. Along the way, though, industry raised a good point, "If this is so good for us, DOD, why don't you try it yourself?" The cognizant focal points of the military services gulped, recognizing that in-house applications might well prove more difficult than those in industry, and bit the bullet.

In particular, the Army set about applying the criteria approach to its arsenals, research and development centers and ammunition plants. Somewhat surprisingly the validation teams were met with open-mindedness, then cooperation and then enthusiasm as managers of facilities began to understand the criteria and to realize the benefits of increased visibility. Currently one arsenal, an ammunition plant and one in-house development facility have been validated or are in process, with three more arsenals and seven additional ammunition plants scheduled for 1974. The same rigor and standards applied to industry are used in these in-house validations.

Understanding of Criteria

There is something a bit mysterious about C/SCSC. Why do organizations in industry and in the Government embrace the criteria concept? What is different about this approach compared to previous management practices? What are the benefits and costs?

To answer these questions, it is necessary first to have some understanding of "criteria." For example, one of the planning and budgeting criteria in the C/SCSC Joint Implementation Guide says, "Schedule the authorized work in a manner which describes the sequence of work and identifies the significant task interdependencies required to meet the development, production and delivery requirements of the contract." It says nothing about *what* scheduling technique must be used. This is left to the contractor who may apply whatever technique he chooses so long as it meets this standard.

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[1] *The pamphlet "Cost/Schedule Control Systems Criteria Joint Implementation Guide," AMCP 37–5, NAVMAT P–5240, AFSCP/AFLCP 173–5, March 31, 1972, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; order no. 0870–0318; price $1.25.*

Another criteria in the Guide, part of the organization group, requires a contractor to integrate his planning, scheduling, budgeting, work authorization and cost accumulation systems with each other, with his work breakdown structure and with his organizational structure. Without this integration, a contractor might plan his work according to technical work to be done, accumulate costs by his functional organization structure, and budget his work according to what funds are available. This situation often existed in the past and is a reason costs sometimes galloped out of control.

Only two things are essentially new or different about C/SCSC from management approaches of the past, aside from its not being a system. One of these is the requirement that management controls must "play" together, as indicated previously. This integration and the use of only one work breakdown structure were new to many organizations, including some of the largest and most experienced defense producers.

The other difference is the concept of earned value, or budgeted cost for work performed (BCWP) as it is known in C/SCSC terminology. Previously a program manager could measure progress against a predetermined schedule and measure actual costs for work performed (ACWP) against a budget. The problem was that the program manager could not determine, for the money spent, whether or not he was getting the progress he should have obtained. How much should he have spent for the progress achieved and how did this compare with what he actually spent? Often he tried to evaluate value by making a "seat of the pants guesstimate," based on percent of funds expended. This is like trying to determine the value of a purchase based on the balance available in a person's checkbook.

Concept of Earned Value

C/SCSC introduced the concept of earned value which enables program managers in industry and the Government to determine, with considerable accuracy, the status of their programs and sub-elements costwise. They do this by comparing BCWP with ACWP. By comparing BCWP with the budgeted cost of work scheduled (BCWS), they can measure actual and planned progress in terms of the cost to come from a behind schedule position to on schedule.

If terms like BCWP, BCWS and ACWP sound like jargon that will soon go out of style, two points are worth noting. One is that they have been in widespread use for some years and are destined to be in use for a long time because of general acceptance of the criteria approach. The other is that the terms are used and their meaning is well understood by decision makers at high levels of DOD. Figure 1 is an example of an application of cost/schedule performance measurement.

Benefits

What benefits have resulted from C/SCSC and what, particularly, does it do for the program manager? Here are some examples:

- During a C/SCSC demon-

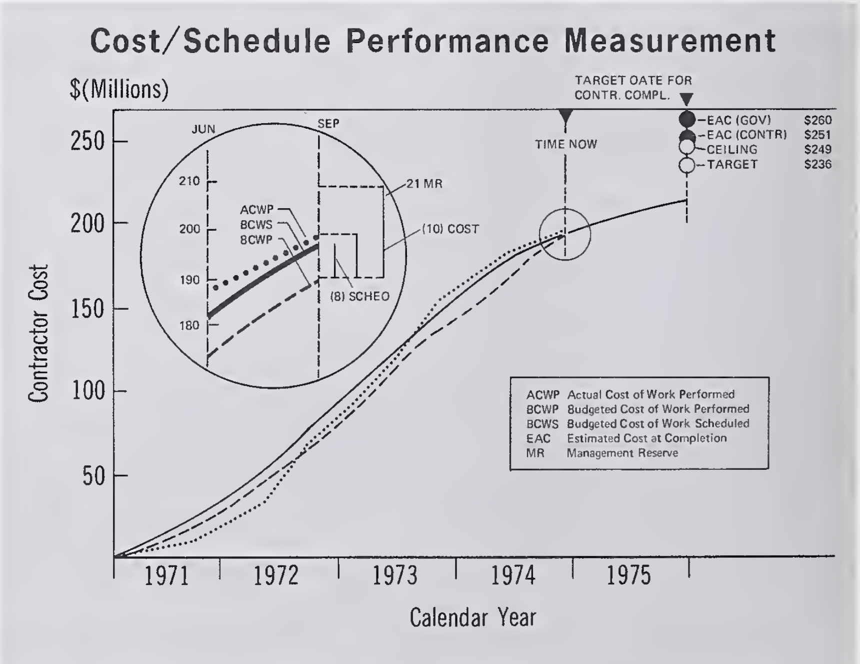

Figure 1

stration, it was discovered that a contractor's manloading curves exceeded the available budget. As a result 5 percent of his personnel were released from the program at a savings of $5 million.

- On a large aircraft development program the cost per aircraft was reduced by $2.1 million when cost visibility enabled the program manager to reduce the use of titanium with only slight effect on performance.
- A contractor on an electronic system traced a problem to a particular individual who had made a mistake that cost $300,000. The contractor estimated that, without a validated system, he would not have detected the problem until during the test phase when it would have cost $2.5 to $3 million.
- On another contract, cost and schedule variances were traced to a rotor blade problem. The contractor was able to redirect his effort and used a different material for the blades.
- In one instance, DOD saved $5 million when a cost performance report showed an overhead cost that should have been billed to a commercial activity.
- On a missile program, completed two weeks early with a $2 million underrun, the general manager was able to discover and assess the cost magnitude of a serious schedule slippage in time to take corrective action.

Some other benefits of C/SCSC are identification of problems not previously recognized; the ability to trace problems to their source; determining the cost impact of problems; and objective rather than subjective assessment of program status.

Interestingly, the two main benefits in contractors' eyes, even on retrofit applications, are greatly improved overall system discipline and detailed forward planning and budgeting.[2]

Problems

Compared to initial resistance to the criteria, present problems are relatively minor. The fundamental problem has been a lack of understanding in industry and the Government of C/SCSC and how it works. The joint logistics commanders recognized this and established management courses to overcome the problem. In the past 18 months, there has been a significant change in attitude toward C/SCSC.

One of the early problems, for instance, was rigidity on the part of Government validation teams as to length of work packages and levels of the work breakdown structures. These teams have subsequently adopted a more flexible position without sacrificing the intent of the criteria. Another problem was that initial applications were retrofits to programs that had been under way for some time. These retrofits were difficult and painful compared to applications at the beginning of a program. Another problem is the effort required to understand the terminology (BCWS, BCWP, ACWP, cost accounts) and to apply these terms in practice.

Cost

The contractor's absolute cost of revising his system to meet the criteria is difficult to measure, but it is generally estimated to be less than a quarter million dollars. Information from several companies indicated there was no cost involved other than the initial computerizing effort. The same number of personnel would be involved on some other technique and C/SCSC is considered by far the best.

The cost is invariably less than one-half of 1 percent of a program, including the nonrecurring costs. This is to be expected, since most of the elements of a compliant system are usually already in use. The best indicator of cost versus benefits, however, is the fact that an increasing number of companies use their validated systems to control commercial and industrial programs.

Outlook

A major part of C/SCSC implementation has been accomplished and attention is turning to surveillance of validated systems. A Joint Surveillance Guide has been drafted and is under review by the joint logistics commanders. Another area receiving attention is use of data; for instance, how to analyze the cost performance report for trends and problem areas.[3]

C/SCSC is no panacea. Good management and technical excellence are required as much as ever. Almost invariably, as individuals recognize its potential as a management tool, they come to feel it is worth a try.

C/SCSC is going to be around for a long time, partly because it is so logical but mainly because it produces results. ☐

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[2] *"The Effect of the C/SCSC on Contractor Planning and Control," doctoral dissertation by Lt. Col. Leonard S. Marrella, The George Washington University, Washington, D.C. February 1973, p. 174.*

[3] *The Army Management Engineering Training Agency (AMETA) offers a course on Managing with Contractor Performance Measurement to military service nominees and, on a space available basis, to industry personnel.*

C/SCSC: Validation Integrity Maintained by DCAS Surveillance Function

In contracts with industry for development and production of major defense systems, a large share of the total Government contract cost is used to purchase assurance the end products delivered will comply with the cost, schedule and technical performance parameters specified in the contract. It is a primary task of the contractor's management to plan and control internal resources and activities in a way that will ensure an effective balance among these three performance parameters throughout the entire process of designing, developing and manufacturing.

In the real world, this balance is continually jeopardized by unforeseen events—necessary design changes, production problems, changing customer requirements to meet changing operational needs, etc. The contractor's internal management planning and control system must, therefore, be responsive to the dynamic nature of the job to be accomplished. A good internal management system can help assure the contractor will deliver a quality item or system on time and within cost targets.

To increase its base of good producers, DOD established the cost schedule control systems criteria (C/SCSC) which is designed to ensure the existence of good contractor internal management systems. The military service contract administration offices and the Defense Contract Administration Services (DCAS) of the Defense Supply Agency play an important role in monitoring and maintaining proper application of C/SCSC to control costs and schedules of defense systems programs.

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DOD Instruction 7000.2, "Performance Measurement for Selected Acquisitions," describes the terms of the criteria which must be met by a contractor's internal management and control system. Normally, C/SCSC will be applied to selected contracts within programs designated as major defense systems and requiring cumulative financing for research, development, test and evaluation (RDT&E) in excess of $50 million, or cumulative production investment in excess of $200 million.

The key word in C/SCSC is *criteria.* Recognizing that many good contractor management systems exist, DOD application of C/SCSC will *not* impose a specific management system on the contractor. The contractor's management system, however, must satisfy certain requirements that allow both producer and customer to apply necessary controls. When controls are proper, the producer's problems are minimized and the customer is more likely to get what he ordered.

C/SCSC is not applied to all types of defense contracts. Under a firm fixed price contract, the contractor assumes the risk of cost and schedule overruns and its accompanying consequences. If his management system is not producing an efficient operation and if contract status is not visible to allow timely application of management controls, he will overrun and lose profits.

Conversely, when the contract is a cost sharing type (cost plus incentive fee, fixed price incentive fee, etc.), the Government becomes a party to the final cost position. Good contractual performance by the producer means a lesser cost to the consumer and for this reason the Government is obligated to guarantee, among other things, that a good contractor management system exists. Although the detailed design of a contractor's internal planning and control system is the responsibility and prerogative of the contractor, ultimate responsibility for assuring availability of an operating end item on time and within cost targets rests with the Government.

Since the achievement of these objectives is largely dependent on the contractor's effectiveness in planning and controlling the tasks which have been contracted to him, the Government is vitally concerned with the adequacy of his planning and control function. To achieve reliable visibility of the contractor's adequacy of planning, the Government must use the same data the contractor used in preparing his plan.

Requirements of C/SCSC

Inclusion of C/SCSC in a contract requires specific capabilities the contractor's internal planning and control system must possess to be acceptable to the DOD system program manager. The criteria is similar in many respects to a technical performance specification because the contractor is required to demonstrate the planning and control functions in his management system meet the requirements of the criteria. C/SCSC is, therefore, not a system but a set of criteria to which the contractor's internal planning and control function must be able to respond.

Briefly stated, C/SCSC requires the contractor to define the work required to meet contract objectives, assign the work to specifically identified organizational elements, establish internal schedules and budgets, and periodically compare actual cost and schedule performance against the planned budgets and schedules. The sum of the internal budgets, plus any management reserve, must always equal the total contract target cost plus the estimate for authorized but not yet negotiated work. This ensures all authorized work is treated in the same manner.

Variances resulting from these comparisons provide DOD and contractor managers with cost and schedule performance indicators enabling them to:

- Determine program progress by specific element of work.
- Identify problem areas and their significance to the source so corrective action can be taken.
- Evaluate organizational performance.
- Have a factual basis for projecting future cost and schedule performance.

Demonstrating C/SCSC Compliance

Verification of contractor compliance with C/SCSC requirements normally occurs when the contractor demonstrates the operation of his internal system to a team of Government representatives. The team consists of representatives from the major military service acquisition commands, the Defense Contract Audit Agency and, where applicable, the Defense Supply Agency's Defense Contract Administration Services which conduct specific tests to determine the system is actually working as described by the contractor. Any variances from C/SCSC requirements noted during the demonstration are brought to the attention of the contractor with a requirement for him to submit a plan for correction. When that plan indicates the C/SCSC requirements have been satisfactorily met, surveillance of the contractor's internal system is accomplished as a normal contract administration function by the DOD agency which has cognizance for the contractor's plant.

If plant cognizance is the responsibility of the Defense Contract Administration Services (DCAS), its surveillance responsibilities commence immediately upon award of the contract. DCAS designates a C/SCSC monitor with the proper industrial engineering background and specialized training. The monitor's Phase I surveillance efforts, which occur prior to validation of the contractor's management information system, are primarily concerned with upgrading the system to the level required by the criteria. An interim surveillance plan is required during that period and the monitor must maintain coordination with the DOD system program office.

When it becomes evident the contractor has achieved the necessary system integrity to comply with the criteria, the military service system program officer convenes a readiness review meeting, at which the representatives of the system program office, the contractor and the DCAS office review the contractor's internal policies and procedures and verify there is reasonably good probability his management system will operate in compliance with the criteria. After a successful readiness review, operation of the contractor's management system undergoes an extensive evaluation process conducted by a representative from the military service system program office, DCAS and the Defense Contract Audit Agency (DCAA). This evaluation process is called the demonstration review and, if C/SCSC compliance is successfully demonstrated, the contractor's internal system is validated as capable of giving management visibility at all program levels of performance with the required reliability and confidence.

Phase II Surveillance

After validation of the system, Phase II surveillance begins during which the DCAS monitor's efforts are focused on making sure the contractor's system is maintained at the degree of effectiveness it demonstrated when validated. A Memorandum of Agreement is negotiated with the military service program office which clearly delineates responsibilities of the program office and the DCAS organization. It sets the framework for a more detailed DCAS and DCAA plan to accomplish the C/SCSC maintenance and surveillance functions. The objectives of C/SCSC maintenance and surveillance are to:

- Maintain the contractor's management control system at the same degree of reliability that it demonstrated when it was validated through sampling and reconciliation of data from all levels of the work breakdown structure and the contractor's external and internal reports.
- Assure that both the contractor and DCAS elements utilize the same data to accomplish their management or surveillance functions.

In performing the maintenance and surveillance function, DCAS relies heavily on the team concept. Recognizing that no one person possesses the necessary skills required to assure no degradation of system, the C/SCSC monitor is assisted by a team composed of other DCAS elements and the Defense Contract Audit Agency. The DCAS elements that provide assistance to the monitor are normally the administrative contracting officer and industrial specialists. Other elements may be used as the occasion necessitates. In this fashion the contractor's system is reviewed monthly in a planned sampling approach which ensures all of the various individual parts of the validated system remain unchanged. The results of the DCAS and DCAA maintenance and surveillance efforts are maintained by the C/SCSC monitor in chronological fashion, thereby providing a readily available historical reference.

Effective Management Technique

In summary, the specification approach of C/SCSC as a contractual requirement offers flexibility to contractors in selecting systems and techniques best suited to their own internal needs while still satisfying the requirements of the Government. The basic concept of establishing and maintaining a plan against which to measure actual accomplishment is one of the most fundamental management principles, regardless of the product or task involved.

C/SCSC does not impose any reporting requirements on contractors. It does require his system to have the capability for generating certain data elements that can be summarized for his internal use and for meeting contractual reporting requirements. Various displays of these data elements (budgeted cost for work scheduled, budgeted cost for work accomplished and actual costs) arranged by the contract work breakdown structure items or organizational elements provide an excellent portrayal of overall contract status.

The requirements of C/SCSC are practical and there are many ways in which the requirements can be met. Nothing new has been invented except possibly a more effective way of achieving the end objective of improved planning and control by both contractor and the Defense Department. ☐

C/SCSC Analysis: The Time Is Now

When the cost/schedule control system criteria (C/SCSC) became official DOD policy in the late 1960's, emphasis was initially concentrated on validating the internal management systems of major defense contractors. This was quite logically the first of a 3-step procedure to implement C/SCSC. The next step was to formulate policies and procedures to monitor the contractor's management system to ensure it continued to comply with the criteria. The time has now come to place considerable emphasis on the third phase, the analysis of performance information coming from contractors validated under C/SCSC.

Now that the first two phases have been implemented and the contractor's management systems are continually generating valid data, the real exploitation of C/SCSC is at hand. While there is significant benefit to be obtained from the discipline attained by compliance with the criteria, the payoff to both the contractor and the Government is in effectively using the resulting data to actually manage a defense system acquisition program.

Even though the analysis phase has not received major emphasis, neither has it been totally ignored. The Air Force Systems Command and the Army Materiel Command have published booklets offering suggestions and techniques on how to analyze data resulting from systems validated under C/SCSC. In addition, the various DOD schools[1] which offer C/SCSC-related courses provide varying degrees of analysis instruction. However, in a re-

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[1] *Courses related to C/SCSC are offered by the Defense Systems Management School, the Army Management Engineering Training Agency and the Air Force Institute of Technology.*

cent study conducted by the Defense Systems Management School (DSMS), it was found that neither the booklets nor the courses adequately cover the latest developments in C/SCSC analysis. In addition, they do not appear to satisfy all of the existing analytical needs of the program management community.

The objective of the 3-month study conducted by DSMS was to investigate ways of improving the use of performance data coming from contractors validated under C/SCSC. During the process of the investigation, numerous people at all levels, both in and out of Government, were interviewed to determine the level and extent of current data analysis and the techniques and/or methods available for improving the analysis effort.

Four problem areas related to C/SCSC analysis were discovered and, briefly stated, are:

- General lack of effective communication regarding C/SCSC analysis within the program management community.
- Reluctance to use the computer and/or operations research approaches.
- Failure to understand and incorporate significant factors such as overhead, the contractor's management philosophy, general economic trends and the impact of technical performance in the total analysis picture.
- Difficulty in analyzing schedule variance and predicting a Government estimated cost to complete, including estimated overrun or underrun for all authorized work.

Communication

The lack of communication was particularly disturbing since a number of potentially successful techniques were found. These techniques ranged from simple analytical hints to vastly different analytical approaches, including the use of computer graphics and sophisticated operations research methods, all of which are almost totally unknown to the general program management community.

Even within a particular command, potentially successful techniques do not necessarily transcend program office boundaries. At one installation where a school and a program office were located, the school had, in fact, developed a technique for analyzing one of the program office's most vexing problems. However, until representatives of both organizations were interviewed during the DSMS study, neither the program office nor the school knew of the other's respective problem and possible solution. Effective communication can enhance the existing C/SCSC analysis capability.

Use of Advanced Techniques

Related to the communication problem is the apparent reluctance on the part of program offices to use more sophisticated analytical techniques involving the use of a computer. Within a few Army and Air Force program offices, computers are being used effectively but, generally speaking, little or no continuous use is being made of a number of approaches which are available and, in some cases, designed specifically for DOD program management. Part of the problem is that a number of analysts within the program offices have neither used nor been trained to use a computer and/or operations research methods. A large measure of this reluctance can be attributed to the individuals responsible for actually presenting and promoting more advanced analytical procedures. It appears that in the past the communications concerning these procedures have been poorly coordinated and, in many cases, difficult for the nonprofessional to understand.

A case in point is the existence of at least six automated techniques [2] for analyzing data contained in the cost performance report.[3] With one exception, none of these techniques is widely known even within one military service, much less in the entire program management community. At least three of these techniques could be considered analytically sophisticated [4] and many analysts in program offices would probably have difficulty in fully understanding their supporting documentation. In addition, there does not appear to have been any attempt to conduct in-depth or independent reviews of any of these automated approaches to offer unbiased and expert guidance on when and where they should or should not be used. It does appear that some emphasis is needed to improve the coordination, documentation and review of the more sophisticated analytical techniques which have been or will be developed.

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[2] *Two of the techniques were developed by an Army commodity command, two by Air Force systems divisions, one by an Army school and one by an Army program office.*

[3] *The cost performance report is the basic performance report resulting from C/SCSC; the format for the report is outlined in DOD Instruction 7000.10.*

[4] *Includes a modified least squares approach, a bayesian approach and a time series analysis approach.*

Scope of Analysis

The third problem is a tendency on the part of some program offices not to incorporate into their analysis all of the significant factors affecting contractor performance. To say that large-scale military acquisition is a very complex business is an understatement. For that reason, it is unrealistic to think that an adequate management analysis can be based strictly on contractor-furnished reports, specifically the cost performance report.

Overhead, the contractor's management philosophy, general economic trends and the impact of technical performance are just some of the areas that should be considered in a complete C/SCSC analysis. Not only must the analyst be encouraged to broaden the scope of his examination, but he must also get the necessary support from staff economists, program engineers, surveillance officers, etc., to provide the input for broadened analyses.

Cost Performance Report

In the fourth area of difficulty, two special analytical problems were found. The cost performance report currently reflects schedule variance in terms of dollars and not as a function of time—days, weeks, etc. Frequently, it is not easy for a program manager to relate an unfavorable schedule variance of $500,000 to the various program milestones or the initial operating capability. There are a number of techniques available in attempting to solve this problem but, with one possible exception,[5] all of those observed during the DSMS study had serious weaknesses.

Another specific analysis problem area is the difficulty in determining a reasonably accurate method for predicting a Government estimated cost to complete. The monthly cost performance report furnishes the program office with the contractor's estimated cost to complete which, to a large extent, is determined subjectively based on the contractor's experience and expertise. In an attempt to verify the reasonableness of the aforementioned estimate, a large number of quantitative techniques have been developed and tried by various Government analysts. In fact, all six automated techniques mentioned previously will provide an estimate at completion to 10-digit accuracy. The confusing point is that all six techniques will normally yield six different estimates at completion. Emphasis needs to be placed in this area to first determine whether a reasonable quantitative approach is available and then decide the limitations to this approach.

Plans for Improvement

An analysis of the problem areas revealed by the DSMS study indicates there is considerable room for improvement in the area of C/SCSC analysis. Increased emphasis could be placed on:

- Improving the dissemination of information throughout the program management community concerning successful techniques developed within various program offices, major acquisition commands or systems divisions, military service headquarters and schools.
- Increasing potential usefulness to the program management community of the more sophisticated techniques, which presently exist, by having independent experts conduct reviews of the techniques to explain in nontechnical terms the basic assumptions underlying them and offering easy to follow guidance on their use.
- Identifying those areas where C/SCSC analysis is weak and initiating action to either increase analysis support or develop the required analytical tools.

The Defense Systems Management School plans to exert considerable effort in the area of C/SCSC analysis during the coming months. Tentative plans include the publication of a handbook highlighting those manual or automated analytical techniques and approaches which the study indicated were most successful. In addition to the proven methods, the planned handbook will discuss a number of the more sophisticated techniques in easy to understand terms. Also on the planning horizon is a conference sponsored by DSMS to specifically discuss C/SCSC analysis.

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[5] *The Army Management Engineering Training Agency has developed an automated technique, called Project Performance Assessment Technique, designed to be used with the cost performance report and a milestone report to provide schedule variance in days.*

DSMS is also planning to conduct and/or sponsor research in the C/SCSC analysis area. One area, in particular, which will be investigated is the use of interactive computer graphics to support analysis needs of program management offices.

The increased emphasis on C/SCSC planned by DSMS will help solve some of the problem areas that have been identified. Complete elimination of these problems, however, will require a shift in emphasis throughout the DOD program management community. ☐

Books Available on Management Concepts

American Management Association's Communications Division (AMACOM) has available several books for individuals interested in additional exposure to management concepts.

One of AMACOM's more recent publications, "How to Manage by Objectives," by John W. Humble, delineates the possible achievements one can attain with management by objectives and how it can be an organizational aid leading to increased productivity.

A book list is available upon request from AMACOM, 135 West 50th Street, New York, N.Y. 10020.

C/SCSC Implementation Guide Reflects Evolution of the Program

In keeping with the spirit of flexibility in the cost/schedule control systems criteria (C/SCSC) and because of its evolutionary development, the three military departments issued a joint implementation guide[1] in March 1972. The guide is the product of the cross-fertilization of ideas and experiences of the three departments and, perhaps most importantly, defense contractors involved with C/SCSC.

The guide itself is significant for several reasons. While much effort preceded the Air Force implementation of cost/schedule, planning and control systems (C/SPCS) in 1967, the evolution of the program since that time has been dynamic. The most salient point is the change of attitude which has taken place within DOD and among defense contractors. The move from adversary roles to cooperative, complementary roles has certainly altered the working relationships between contractors and the Government.

The manner in which the guide evolved had much to do with alteration of attitudes and contributed significantly to the success of the C/SCSC program. The evolutionary history of C/SCSC has been recorded elsewhere.[2] This article will cover the manner in which the guide evolved and the changes it brought about that contributed to the program's success and facilitated its continuance.

C/SCSC resulted from the realization a contractor receives payment not only for a defense system development and production program but also for management. To manage the program, the contractor needs some method of internal control and, since the contractor presumably has a management system, why not use it? A Government imposed system, at best, was a two-system management approach: one for the contractor's internal use and another to report to the Government. At worst, the quality of the second or imposed system deteriorated to the extent that the information derived there-

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[1] "Cost/Schedule Control Systems Criteria Joint Implementation Guide," Departments of the Air Force, the Army, and the Navy, AFSCP/AFLCP 173–5, AMCP 37–5, NAVMAT P–5240, March 31, 1972.

[2] Lt. Col. Robert R. Kemps, USAF (Retired), "Contractor Performance Measurement," *Defense Industry Bulletin*, Summer, 1971, pp. 42-48. Also Brian R. Durbrow, *Readings in Cost/Schedule Control Systems*, Air Force Institute of Technology, revised 1974.

from was of little or no value, system discipline ceased to exist, and general lack of enthusiasm for it caused the system to become defunct. With C/SCSC, the decision was made to utilize the contractor's internal management system already in being, thereby avoiding the previously mentioned problems.

Since every contractor manages a little differently, almost every contractor's management system is different. The C/SCSC approach was the answer to the problem of how to be consistent in contractor performance measurement, while allowing contractors to use vastly divergent systems. Provision of the criteria did no more than set forth what DOD perceived as good "common sense" management or functions that a good management system should be capable of doing, with the contractor determining the "how."

DOD took a common sense approach in cooperation with industry as opposed to a theoretical approach. The behavioral management concept that active participation breeds involvement, interest, cooperation and acceptance was successfully put into practice.

Program Thresholds

While DOD Instruction 7000.2, "Performance Measurement for Selected Acquisitions," December 1967, and the guide were in the throes of revision, DOD Directive 5000.1, "Acquisition of Major Defense Systems," was issued in July 1971 calling for, among other things, an increase in the thresholds for the application of C/SCSC. To be consistent, both the guide and DOD Instruction 7000.2 were revised to be in consonance with the overriding policy of DOD Directive 5000.1.

Investment thresholds have been elevated from $25 million to $50 million for research, development, test and evaluation (RDT&E) and from $100 million to $200 million for production. On any defense system acquisition that exceeds these thresholds, application of C/SCSC becomes a mandatory requirement in the contract. At first glance, the increased thresholds appear to open the floodgates; however, it must be remembered the threshold levels are for total program costs as anticipated in the Five-Year Defense Plan. The thresholds *per se* do not apply to individual contracts but to total projected program costs. If the total projected investment is expected to breech the thresholds, then inclusion of C/SCSC is automatic.

Another point to remember is that the raised thresholds do not preclude the application of C/SCSC on programs of substantially lower dollar volume. There may be just cause for applying the criteria to other programs or specific contracts such as programs designated by the military departments as major system programs of national interest or urgency, and programs of interest to DOD or the Congress because of their critical nature, risk involved or national security. These exceptions to the thresholds, in effect, allow for the application of C/SCSC to almost any contract or program (other than firm fixed price) in excess of several million dollars if it is deemed desirable. The C/SCSC Guide states that deviation from the thresholds is authorized by the specific approval of the cognizant DOD acquisition command.

Approach to the Guide

One of the biggest problems of the 1970 Joint Implementation Procedures revolved around the word "procedures" in the title. There was a tendency to interpret C/SCSC as inflexible, "locked in concrete" so to speak, and its implementation became narrow, rigid and procedural in nature. In the 1972 Joint Implementation Guide, the word "guide" was a deliberate choice to emphasize flexibility in interpretation. With variables in every contractor's management control system, the only way for one set of criteria to be equally applicable to all systems was to allow for flexibility in interpretations.

The common sense approach is not easy. It requires both the DOD team members and contractor personnel to think with a capital "T" because each situation must be reviewed as it is and how it relates to the way the contractor actually manages. DOD personnel cannot look at one contractor's system and think it is wrong because another contractor did it some other way and his system was validated. It also means that contractors need to avoid the "look alike syndrome" and concentrate on what makes sense for their individual systems.

Contractor Appeals

With legitimate reason, contractors in the recent past have been concerned about the apparent power of DOD personnel—the DOD demonstration teams—who evaluated their management control system to determine its compliance with C/SCSC. Under the old procedural way of conducting validation exercises, it unfortunately was not uncommon for a team chief to tell an exasperated contractor that his management control system did not comply with the criteria and, unless the contractor's system was changed, the team chief would not recommand validation, period. Whether the team chief's demand was reasonable or unreasonable, rational or irrational, was not relevant; the contractor either complied or he did not receive a letter of validation.

Since the issuance of the C/SCSC Guide, however, recognition has been given to the fact that honest people have honest differences of opinion. If disagreement arises between the contractor and the team chief, the contractor has an appeals route to follow for adjudication of the disagreement or to air substantive problems pertaining to the interpretation of the criteria. When a problem develops, the contractor goes to the team chief for its resolution and may eventually reach the military service Secretary, if necessary, until he believes the problem—real or imagined—has been properly adjudicated.

Cost Accounts and Work Packages

An area of C/SCSC which has frequently been subject to misinterpretation is the duration and size of cost accounts and work packages. C/SCSC implementation procedure required "short span" work packages and cost accounts of "limited size and duration" in an effort to minimize in-process effort. What these phrases meant was never explained. In the evolutionary process, someone once said "short span" means on the average about eight weeks. With this quantification of the term, contractors proceeded to break up all work into 8-week time frames, educational materials began using it and, in short order, what was intended as a rule-of-thumb became hard and fast gospel. The guidance intended became lost in the translation.

The requirements have been segregated from the rules-of-thumb in the C/SCSC Guide. Certain generalized rules will persist, but what needs to be emphasized to those involved in C/SCSC is that there are significant differences between requirements and guidelines. The military services, by way of guidance, are still looking for short span work packages; however, the requirement is that work packages represent the way the work is being done, whether it takes 4, 8 or 20 weeks. The C/SCSC Guide attempts to make this point clear to practitioners.

Control of Indirect Costs

Both the C/SCSC checklist and the demonstration procedures have been expanded in the area of indirect costs. The expansion reflects a recognition by the military services that there is as much need to be concerned with indirect costs as with direct costs. Close inspection of the expanded area reveals that most of the procedural tests suggested in the C/SCSC Guide are still to be performed with direct costs in mind; nonetheless, the changes do reflect a move in the right direction.

The expanded checklist now includes 11 accounting items concerned specifically with indirect costs. The guide also delineates the types of tests the Defense Contract Audit Agency (DCAA) normally applies to the area of indirect costs. Since DCAA typically performs this part of the evaluation, its consistency is beneficial to both the contractors and the military services because both parties are now cognizant of how indirect costs included in the management system are evaluated. The checklist items contained in the guide do no more than build upon the normal audit function relative to indirect costs.

Accounting for Materials

Since the inauguration of DOD Instruction 7000.2 in 1967, an item of considerable interest has been the accounting for material. Specifically, discussion has revolved around the definition of applied direct costs of material or the accounting for material at the point of usage. The point of contention by contractors has been the alleged narrow view of the military services and the contractors' desire that the services accept a method of recording actual costs of material on a basis other than at the point of usage.

The initial interpretation was to simply record the actual costs at the time material became a part of in-process work. In an evolutionary way, the narrowness of this interpretation was expanded to include uniquely identified serial end items on material expected to be incorporated into in-process effort within the current or next accounting period. This practice has now evolved into a rule-of-thumb which is being interpreted to mean material to be utilized within 60 days. Consequently, many contractors now comply with the criteria by accounting for material costs up to 60 days before it actually is placed into usage. While this was not the original intent, it has become accepted practice.

The cause of the controversy arises primarily because one loses sight of the purpose of C/SCSC. The intent is to have a management system which accurately indicates at what point in the contract the contractor is performing as compared to where he intended to be and how much it actually cost to get where he is—in other words, a performance measurement system. Accounting for material at point of usage suggests the material has entered the process and work is being performed on or with that material and the earned value concept of performance measurement should come into play. Even if the material has been paid for and the contractor has received progress payments, there is no contract performance earned value if the material has not been used. Material on the dock or in inventory is not the same as work being performed (earned value) and to treat it as such distorts the actual earned value or measurement of work progress on the contract. Figure 1 illustrates a typical material flow.

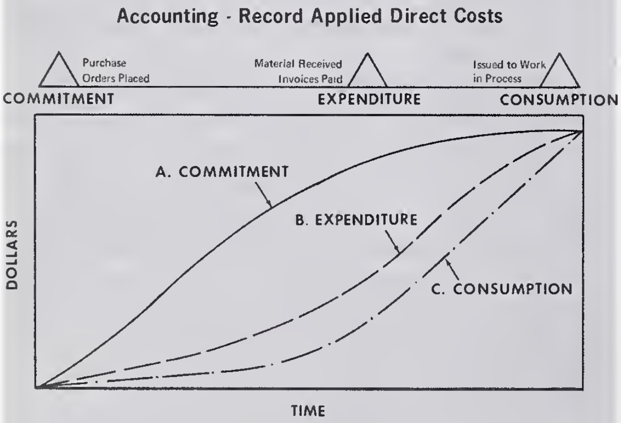

Figure 1

Subcontractor Evaluation Reviews

A long-standing question has been that of the conduct of subcontractor evaluation reviews when C/SCSC has been placed in a subcontract by the prime contractor at the request of the procuring activity. Who conducts the demonstration review? The old procedures, to the dissatisfaction of almost everyone, were quite explicit on this matter, simply stating, "Requires contractor to conduct demonstration reviews of systems operated by major selected subcontractors." Clearly the intent was for the prime contractor to be responsible for the action.

However, problems arose from the beginning. In some cases prime contractors had been evaluated and their system found to be in compliance but they had failed to validate their subcontractors. Since validation of subcontractor systems was part of the C/SCSC clause in the prime's contract, DOD intimated the prime was not in compliance and, therefore, his management system could not be validated. In other cases, prime contractors were accepting and validating subcontractors when their own systems were not acceptable, thereby making the subcontractor's validation suspect. In other situations, subcontractors were complaining about a multitude of idiosyncrasies being levied upon them by different primes, a definite problem when a subcontractor is simultaneously supplying two or more prime contractors.

There were situations where subcontractors refused to open their books to the prime, indicating the information was proprietary and, furthermore, the relationship between the subcontractor and prime might be reversed with the next contract, causing competitive problems. Subcontractors were also complaining that a prime's validation of their system was only acceptable for additional subcontracts to that prime. A contract with any other prime required a new evaluation process which is both time consuming and costly. In short, what appeared to be a simple requirement became a thorn in everyone's side.

The new guide, while not totally solving the problem, moved in the direction of removing some of the thorns by stating, "reviews of these selected subcontractor's management systems may be performed by the procuring authority in coordination with the prime contractor." The result has been reviews conducted by a military service and the prime contractor or, if more than one military service is involved, a team representing the services and the prime contractor. The determining factor seems to be what all parties concerned can agree to at the time. DOD, in fact, contracts with the prime contractor and not the subcontractor and DOD's concern should be how the prime contractor manages the subcontractor.

Memorandum of Understanding

The inclusion of the requirement of a Memorandum of Understanding in the Joint Implementation Guide is aimed at accomplishing several things. It suggests that evaluations conducted by one of the three military services, when undertaken using the standard implementation guide, should be acceptable to any of the three services. The implications and ramifications of this procedure are obvious.

The Memorandum of Understanding also facilitates the contractor's responses to a Request for Proposal (RFP). One of the items included in an RFP is a request for detailed information pertaining to the contractor's management system and how he expects to comply with the C/SCSC requirement. To be able to respond with a Memorandum of Understanding, which in effect says the contractor has an accepted system complying with the requirements of DOD Instruction 7000.2, is an obvious advantage to all parties concerned.

Finally, the use of a Memorandum of Understanding adds credence to the criteria, implying its recognition by the contractor and, perhaps more significantly, indicating the three military services agree on a common set of requirements and the acceptability of another service's evaluation review.

Revision to Cost Plan

The criteria require the contractor to establish and maintain a time-phased budget baseline at the cost account level against which contract performance can be measured. Initial budgets comprising the baseline are to be based on contract target cost, with any other basis formally recognized and accepted by both the procuring activity and the contractor. The contract budget and performance measurement baselines should be reconcilable at all times. The difference between the two reflects funds retained by program management as a management control technique, generally called management reserve. For accurate measurement of contract performance, the performance baseline must reflect the contractor's internal operating plan. The criteria specify that the performance measurement baseline must be identified to the budgets or standards comprising the work authorization system.

To avoid distortion of already reported performance, the criteria prohibit the contractor from making retroactive changes to budgets. This does not prevent changes to downstream effort which reflect internal replanning of future effort and are totally acceptable so long as they are fully documented, reflected in the performance measurement baseline and reported to the procuring activity. The majority of these changes will alter the performance measurement baseline as funds are moved out of or into management reserve, *i.e.*, the performance measurement baseline will remain below the contract budget baseline.

On occasion, due to some calamity, internal replanning may be of such magnitude that the performance measurement baseline will exceed the contract baseline. In such a situation, fully documented changes and reconcilable baselines must be submitted by the contractor to the procuring activity for formal acceptance. Frequent changes of this nature are not acceptable to DOD because of the lost visibility.

Fee Adjustments

When a formal adjustment to the performance measurement baseline above contract target cost is requested and the revision to the cost plan has been accepted by the Government, the profit or fee on incentive type contracts must be adjusted to reflect a higher than target cost estimate at completion. In other words, acceptance of a requested baseline change must carry with it a lower profit rate than was negotiated for attainment of contract completion at target cost.

This concept is reflected in Figure 2 (see next page). Point A reflects the fee to be paid at target cost. Point B is the fee rate associated with an over target cost baseline. In reality, Point B will slide along the incentive fee line, depending upon where the new baseline indicates the cost at completion is likely to be. Consequently, whenever a formal adjustment to the baseline is contemplated both parties need to be cognizant of the simultaneous reduction in the percentage rate of the fee to be paid.

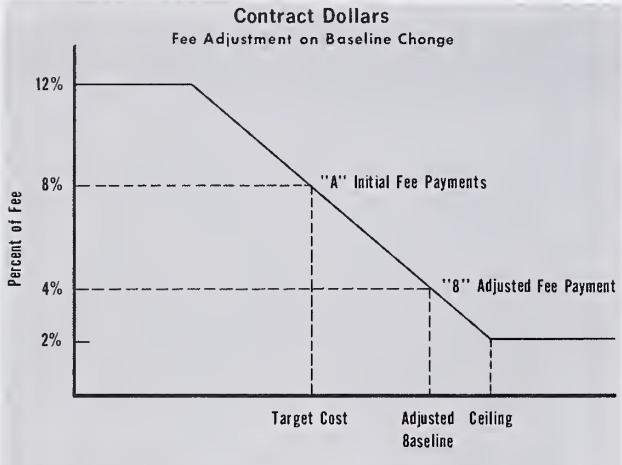

Figure 2

Despite the historical difficulties encountered with C/SCSC, it has become an acceptable method by which the Defense Department and defense contractors can trace system acquisition expenditures. Both parties seem to have learned that blind adherence to a rule-of-thumb could, in some cases, lead to excessive detail; in others the result is gross, meaningless generalities. Consequently, whether one is developing or evaluating a system, the significant point remains—the control of cost and scheduling should bear a direct relationship to the type of work being performed. It is this relationship which needs to be evaluated with common sense, not an inflexible view of the dollar amount or the specific length. Each contractor has his own application and it is that application which must be reviewed in terms of logic, applicability and reasonableness in relation to that contractor's operations. □

Neither ambition, social snobbery, nor self-assertion will serve to create a profession or define its area of autonomy; these will in the long run be determined by the function fulfilled.—Willard Hurst

New Wrinkles in Improvement Curves

Auditing is a specialization within the accounting profession and, while accountants are generally provided with a substantial background in mathematics, they are not mathematicians. Yet many of the daily analyses performed by auditors of the Defense Contract Audit Agency (DCAA) to assist DOD procurement activities in negotiating fair and reasonable prices under defense contracts, can involve complex mathematical computations. The application of improvement curves is a case in point. To assure its auditors use the latest and most advanced techniques, DCAA has developed computer programs to perform the complex mathematical computations involved in learning curve applications and made them readily available to virtually every auditor through time-shared computer services.

DCAA contracted for time-shared computer services in January 1967. Within three months, standard programs to fit improvement curves and regression models, and select and evaluate statistical samples were developed by DCAA and utilized in field applications. By the end of 1967, teletypewriter terminals had been installed in all DCAA regional offices and arrange-

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ments had been made with several major contractors for DCAA use of their terminals. Since then, programs for more advanced statistical analyses have been developed, and all DCAA branch offices and major residencies at contractor locations now have access to either Government or contractor acquired terminal facilities.

By eliminating the need for time-consuming manual calculations, time sharing quickly led to a rapid increase in DCAA use of improvement curves, regression analysis and statistical sampling. Time sharing also virtually eliminated the possibility of mathematical errors and permitted the use of advanced statistical techniques which would not otherwise be feasible.

Need for Progress

A mathematical formula expressing the relationship between the number of units produced and the direct labor required for each unit was first formulated by T. P. Wright in 1936.[1] This formula, when plotted on full logarithmic graph paper, is represented by a straight line, usually sloping downward, reflecting lower costs due to learning and work improvements. The costs of subsequent units of production were, therefore, projected by either visually fitting a freehand line of sight to the historical data plotted on logarithmic graph paper or mathematically applying the formula to the historical data, depending upon the degree of accuracy desired.

Since performing the mathematical process manually is long and tedious, practicality often dictated use of the visual method. However, for purposes of negotiating a defense contract price, it is in the best interests of both parties to eliminate the judgmental and potentially biased positioning of a line through plotted points and the subsequent reading of the projection. Sometimes the width of a pencil point can cover a significant range of projected labor hours or costs. As the computer programs to perform these calculations became accessible to auditors working with improvement curves, the mathematical obstacle was removed. In less time than was required to plot historical data and draw a freehand line of sight, the computer was able to compute the indicated rate of improvement and make projections more accurately for any desired quantity.

Improvement curve applications may be made under either the unit curve or the cumulative average theory. Because of the variety of products and accounting systems encountered, DCAA auditors must be prepared to apply either of these theories, and they must have the flexibility of applying them to cost data for individual units or lots.

The unit curve theory is based on the hypothesis that, as the total quantity of units successively produced is doubled, the cost of *each unit* in a sequence of units based on doubled quantities (units 2, 4, 8, 16, etc.) will decline by some constant percentage; *e.g.*, the cost of the 4th unit will be 90 percent of the cost of the 2nd unit. The hypothesis for the cumulative average theory is that, as the total number of units successively produced is doubled, the *cumulative average* cost of each doubled quantity of production, *e.g.*, the average cost of units 1 and 2, of units 1 through 4, 1 through 8, 1 through 16, etc., will decline by some constant percentage. It was the cumulative average theory that T. P. Wright utilized in his mathematical model; however, subsequent studies indicate that the unit curve theory may have more general applicability.

When labor hours are available on each unit, standard computer programs for curvilinear regression analysis provide an accurate fit under the unit curve theory. But unit data is peculiar to products that require a large number of labor hours to produce. DCAA auditors are more likely to be dealing with production costs accumulated by lots, *i.e.*, a designated number of units or perhaps even all production in a specific period of time.

Lot Data Problems

Because we still have the same mathematical formula, whether we have unit data or lot data, two problems with applying the unit curve theory to lot data became apparent to the Advanced Audit Techniques Branch at DCAA Headquarters:

- Conventional methods of calculating lot midpoints are approximations and the least-squares line based on these midpoints is, therefore, also an approximation.
- All lots are assigned equal weight regardless of size.

Similarly, analysis of the

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[1] The theory that the equation $y=ax^b$ can be used to predict direct labor costs (y) in terms of cumulative units of production (x) was first formulated by T. P. Wright of Curtiss-Wright Corp. His findings were presented in an article titled, "Factors Affecting the Cost of Airplanes," published in the *Journal of Aeronautical Sciences*, February 1936.

cumulative average theory as conventionally applied revealed two major shortcomings:

- Cumulative averages are not independent since they include the cost of all prior lots.
- If a unit or lot is eliminated, which for various reasons is often necessary, the formula is inoperative.

To overcome these problems, DCAA developed two computer programs in 1967 known as the unit curve theory for lot data (ICLOT) and the cumulative average theory for lot data (CALOT). Both are based on their respective classical theories, but provide improvement curves which more accurately fit the data than could be obtained by computer programs that duplicate the approximation procedures employed in manual calculations.[2] The usage of these programs by DCAA and their availability in time-shared computer libraries has led to their adoption by many defense contractors.

Production Levels

The success of these two programs became a stimulus for further advancements. In 1968, a project was initiated to develop and test improvement curve models that take into consideration the effect of changes in production levels between periods. This problem is particularly applicable where a production line includes stations which must be manned regardless of the level of production. In such situations, there is a fixed amount of labor that must be incurred at all levels of production for the process to function. In addition to the applicable rate of improvement and the number of units produced in the past, the unit labor requirement for any given unit is also dependent upon the production level during the period that unit was produced. Persistent pursuit through evaluation of case studies resulted in the development of the COLOT (combined) computer program, which became operational in 1970, and is now used by DCAA auditors in appropriate situations. This program combines the unit curve theory model with the effect of changes in production levels.

For the mathematicians, the classic unit curve theory formula is $y=ax^b$, where y is the number of labor hours required to produce unit number x, a is the theoretical value of the first unit and b is a factor which determines the rate at which labor hour requirements decrease with production experience. When labor hours are recorded by production lot instead of by unit, y is the average labor hours per unit in the lot and x is the lot midpoint. The COLOT program uses the formula $y=ax^b+cz$, where z is the number of hours, days or other units of time required to produce the lot divided by the number of units in the lot and c is the fixed labor hours per unit of time. The COLOT program finds values for a, b and c which provide a least-squares fit to historical experience represented by the values of x and y.

Improvement Curve Data Bank

At the same time the COLOT program was being developed, DCAA was analyzing still another problem. Field auditors were experiencing situations to which an improvement curve obviously applied but, because the particular contractor had never produced the item or similar items or because the contractor's records were not susceptible to improvement curve analysis, an appropriate rate of improvement could not be computed. Because of these situations, DCAA undertook a project to gather data on hundreds of improvement curve applications made by field auditors to determine the rates of improvement typically experienced in the production of various categories of products.

This analysis culminated in the issuance of a "Report on Improvement Curve Experience" in 1969 that presented selected data on 236 improvement curve applications with summary analyses. In 1970, this report was revised and updated to include a total of 443 applications and was widely distributed within DOD. Its primary purpose is to enable field auditors to recommend rates of improvement for specific products based on industry averages when available information for a specific contractor is not sufficient to develop such rates. It also provides additional support for audit recommendations based on the improvement curve technique in general. Although contractors were not identified in the report, the end item descriptions and other data presented on each application might enable individuals familiar with the industry to identify individual contractors. For this reason, the report is designated "For Official Use Only" in compliance with 18 U.S.C. 1905 which prohibits the disclosure of contractor financial matters to unauthorized persons.

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[2] A complete discussion of the formulae and methods used in these two programs is presented in a thesis titled, "Methods of Fitting Improvement Curves to Lot Data Based on Assumptions and Techniques of Regression Analysis," prepared by Robert B. Ilderton, Chief, Advanced Audit Techniques Branch, DCAA Headquarters, Cameron Station, Alexandria, Va. 22314. The thesis also presents the rationale for the development of the COLOT, BREAK and STANB programs discussed later in this article.

Diversified Applications

In 1971, it became clear that field auditors needed some means of objectively measuring the "loss in learning" due to a break in production or the "retention in learning" due to a contractor's production of similar items in the past. A project was initiated to analyze case studies and published material on improvement curves to determine if specific guidance could be provided to field auditors. This project resulted in the development of two more computer programs that became operational in 1972.

The BREAK program provides an estimate of the number of units of improvement lost because of a break in production. For example, a contractor proposes to manufacture additional units of an item that he is currently producing; however, there was a break in the production in the past. The BREAK program provides a least-squares estimate of the number of units of retrogression due to the break, fits an improvement curve to the repositioned data and computes the projected requirements to produce the additional units covered by the proposal. The program has also been used to estimate the impact of disruptions in production in relation to evaluations of contractor claims.

The STANB computer program provides an estimate of the number of units of improvement retained from the prior production of similar items and is based on the results of research performed by Stanford Research Institute (SRI) under a 1949 Air Force contract. SRI observed that actual unit labor hour data on World War II aircraft tended to follow a flatter pattern during the early stage of production than predicted by the unit curve theory, and developed a model of the form $y=a(x+B)^b$ to provide a better fit to the data. This study tended to discredit the cumulative average curve theory which predicts a steeper pattern of learning during the early stages of production.

The parameter B in the model became known as the "Stanford B factor," and the usual explanation of its presence is that it takes into account a company's prior experience in producing similar items. For example, if a company has extensive experience in manufacturing a product, it might begin producing a new model of this product at a point on the improvement curve that would correspond to the fifth unit of production for a company with no prior experience. In this case, B would have a value of 4 and the improvement curve would be positioned to reflect this "retention of learning."

Despite the impressive results reported in the Stanford study, the model had not been very widely used, probably due to the difficulty in obtaining a least-squares fit to this model. The STANB program does this. Using the program, the field auditor can compute the number of units of retained learning, the position of the improvement curve reflecting the retained learning, and the projected requirements for the quantity of items being reviewed.

As was the case with ICLOT and CALOT programs, each advancement has stimulated further pursuit to resolve problems encountered by field auditors in applying improvement curves. Through daily use of improvement curves in various situations, DCAA field auditors provide DCAA Headquarters with a continuous appraisal of the effectiveness of existing techniques and identify new problem areas for study and resolution. A complete list of time-shared computer programs developed by DCAA for use in improvement curve applications is presented in Figure 1. These programs are accessible by all Government agencies utilizing time-shared computer services arranged through the General Services Administration.

Savings Achieved

The total amount of savings attributable to improvement curve applications cannot be precisely determined because many defense contractors have adopted the technique as a result of its use by Government auditors and negotiators. Consequently, the costs proposed by these contractors in negotiating new procurements are less than they would otherwise have been. The Government's cost avoidance in such cases cannot be measured. However, the savings that can be identified are those that result from applications of improvement curves to contractor proposals that do not consider historical trends, and recommended cost adjustments where contractor applications of improvement curves are not wholly valid. These savings amounted to $238.5 million over the past four fiscal years.

The following cases illustrate the circumstances and related savings from improvement curve applications:

Improvement Curve Programs

Program	Description
BREAK	Calculates and projects improvement curves that provide an estimate of the number of units of lost learning due to a break in production.
CALOT	Calculates and projects improvement curve under the cumulative average theory for lot or unit data.
CAPRO	Projects under the cumulative average theory when the slope and one value are known.
CAUNI	Calculates and projects improvement curve under cumulative average theory for unit hours or cost.
COLOT	Calculates improvement curves that give consideration to levels of production.
COPRO	Projects improvement curve data based on COLOT analysis.
ICLOT	Calculates and projects improvement curve under the unit curve theory for lot or unit data.
ICUNI	Calculates and projects improvement curves under the unit curve theory for unit hours or cost.
ICPRO	Projects under the unit curve theory when the slope and one value are known.
STANB	Calculates and projects improvement curves that provide an estimate of learning retained from production of similar items.

Figure 1

- A contractor proposed a follow-on production order of 535 units which did not reflect historical experience in the development of the proposed manufacturing hours. The DCAA auditor evaluating the proposal ascertained that historical manufacturing hours for the first 155 units of the predecessor contract were available. Further analysis of this data disclosed that the first 12 units contained unusual and nonrecurring hours. The auditor used the ICLOT program to fit an improvement curve to the hours for units 13 through 155 and to estimate the hours required to manufacture the additional 535 units. The parties agreed with the audit report recommendation, based on this projection, which reduced the proposed cost by $2.6 million.

- In support of a bid proposal for a follow-on contract, the contractor estimated factory labor hours based on actual experience on the prior production contract. The contractor estimated labor hour requirements for each of 60 end items by plotting historical labor hours on log-log paper and visually fitting an improvement curve to these plot points. For additional items where historical data were not available, the contractor estimated labor hour requirements by extrapolating from improvement curves used in developing estimates for the preceding contract. The auditor's evaluation utilized more current and complete production data. In addition, the audit analysis of the data used by the contractor disclosed that recorded hours for some of the end items required adjustment to exclude nonrecurring hours. The auditor processed the adjusted experienced data on DCAA time-shared computer programs and, based on this analysis, projected a 95,000-hour reduction which had a contract value of about $2.8 million that was agreed to in negotiations and reflected in the contract price.

- A contractor estimated manufacturing labor requirements on a major proposal by applying an improvement curve to historical cost data from two prior production lots. The auditor's evaluation included all prior production lots, resulting in a significantly different improvement curve slope from that computed by the contractor. The negotiated firm fixed-price contract reflected a $2 million reduction in cost and profit attributable to the revised improvement curve application.

- The impact of a reduction in monthly production quantities was estimated using the COLOT program. The contractor had been producing the item in quantities ranging from 62,000 to 90,000 units per week using two lines operating on two shifts. Future requirements of 41,500 units per week would be produced using two lines on one shift. The historical data generally followed a 94-percent improvement curve, and the auditor had previously used the improvement curve technique to evaluate proposed labor hours. To give consideration to the reduced level of production, number of shift lines and improvement, the COLOT program was used and the auditor concluded that a projection of .1113 hours per unit was more realistic than the contractor's estimate of .1252. Adjustments at negotiations resulted in agreement at .1150 hours per unit.

Since its establishment in 1965 as the financial advisor to DOD components responsible for procurement and contract administration, DCAA has strongly advocated the use of improvement curves in evaluating contractor cost estimates, and will continue to explore the use of additional advanced auditing techniques. Utilization of improvement curves currently produces annual savings of at least $60 million in procurement costs.

DCAA's success with this auditing technique is the result of maximizing the availability of time-shared computer services to field auditors, a continual program of research and development, and the desire of both contractors and the Government to improve estimating techniques and minimize risk for either party. □

DOD Economic Analysis Council Meeting

The Defense Economic Analysis Council will hold a symposium May 20–21 at the Industrial College of the Armed Forces, Ft. Lesley J. McNair, Washington, D.C.

The theme of the 2-day meeting will be Applications of Economic Analysis-Program Evaluation Techniques. Discussion will center on solution of problems encountered at the field level. Speakers will include Terence McClary, Assistant Secretary of Defense (Comptroller); William Woodruff, Assistant Secretary of the Air Force (Financial Management); and Melvin Baker, Deputy Assistant Secretary of Defense (Systems Policy and Information). The meeting is cosponsored by the National Council of Associations for Policy Sciences (NCAPS).

Further information may be obtained from Capt. Frank Eppler, telephone number 697–0791, autovon 227–0791.

DOD Studies Concepts for Modernization of Depot Storage Facilities

In December 1972, the DOD Logistics Systems Policy Committee Task Group 5–70 (Depot Storage Facility Modernization) completed the second phase of a comprehensive analysis of the state of DOD depot storage facilities and the technology that should be applied to modernize them for the 1980 period.

During the first phase, the task group conducted an in-depth review of depot receiving, storage, packaging and shipping operations, and associated facilities and equipment. Information was compiled from an analysis of 33 DOD storage depots and visits to selected military and commercial activities to investigate potential modernization concepts and technology that should be considered in the modernization program. During the second phase, each of the depot activities involved was analyzed and conceptual configurations of equipment and facilities were developed employing the latest technology.

by Colonel Phillip M. Ozenick, USAF
Chairman, Task Group 5–70
DOD Logistics Systems Policy Committee

The Air Force Institute of Technology (AFIT), Wright-Patterson AFB, Ohio, assisted the task group in the systems analysis work by developing mathematical models to analyze the economics of automated storage systems and assessment of the optimum size of DOD depots.

Depot Size

To plan concepts for modernizing DOD depots, the task group was faced with the basic question of what sizes should be considered. To answer this question, the task group looked at the relationships between the warehousing operating costs of each of the 33 depots and its size. Size measures in terms of tons shipped, line items issued, Federal Stock Number (FSN) items stored and square feet of storage space were used.

Curves were plotted using regression analysis to relate the costs to size. The resulting curves showed a constantly decreasing nonlinear relationship indicating that as the size increases the operating cost decreases. This is, of course, what could be intuitively expected. The interesting feature about the curves was that the operating costs seemed to increase significantly below a depot size of 300,000 FSN items with a much less rate of decrease in cost for FSN items stocked in excess of this level. These empirical findings were only useful as guidelines since there are many other factors (such as differences in commodities) which could have caused the smaller depot operations to reflect a higher cost.

Transportation Costs

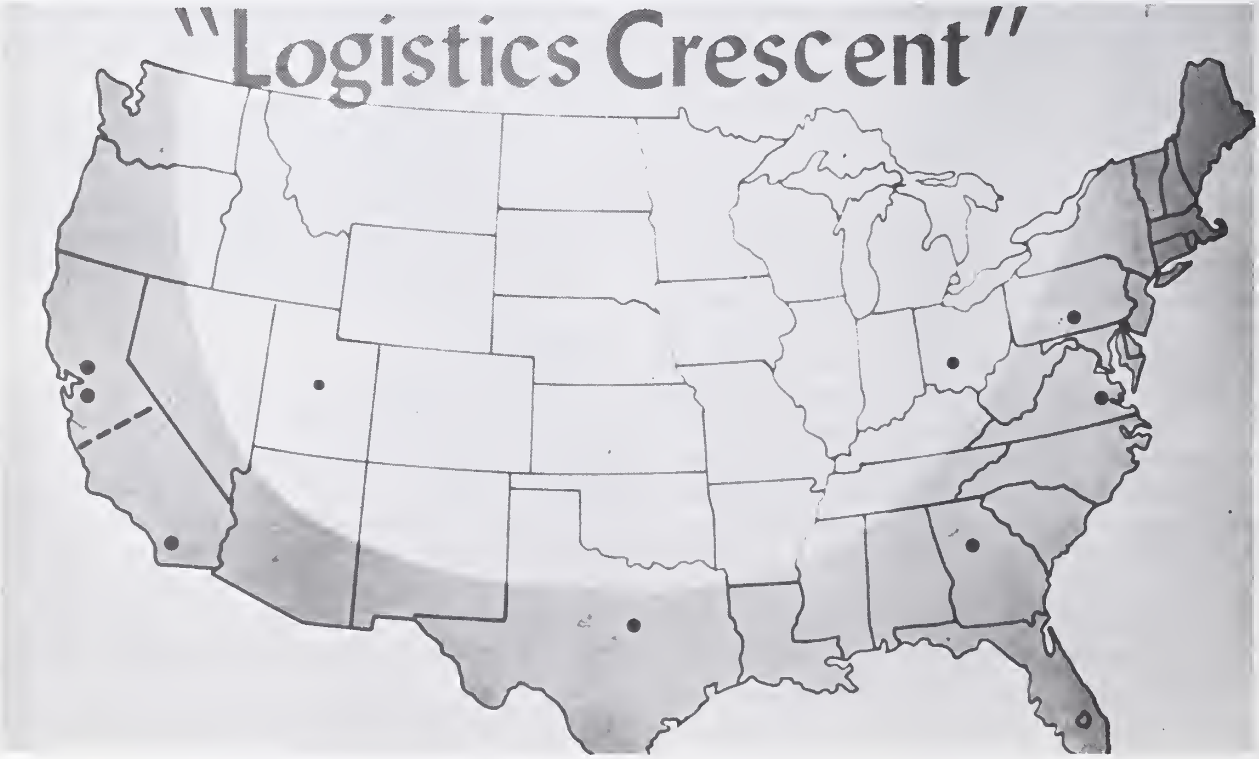
The impact of the cost of transporting supplies from the manufacturers to the depots and, subsequently, to the users, was an important point not previously considered. The economics of consolidating current smaller depots into a system of larger distribution centers, therefore, could not be proven. The cost of transportation could conceivably disprove the findings that eliminating the smaller depots and establishing a system of large distribution centers would be economical.

A mixed integer programming model was developed by the faculty and students of the Air Force Institute of Technology to permit analysts to trade off between storage facility operating and transportation costs. The initial computer runs of this model have indicated that transportation costs do not outweigh the reduction in storage costs associated with large consolidated facilities. In fact, the impact of transportation rates related to depot operating costs was so small that very large—what might be called super size storage depots—can easily be justified economically.

The number of super size depots required to handle the same tonnage as the 33 depots did in 1970 is estimated to be between 8 and 12. The programming model also indicated the advisability of situating the super storage facilities near locations of greatest production and demand. Since the majority of ports, bases and stations are located along or near coastlines of the United States, the predominate locations for super depots would logically appear to be in the coastal states—aptly named the "Logistics Crescent."

Under One Roof

What will the depots of the future look like? The approach of the past has been to seek productivity by installing modern materials han-



Artist's concept of Logistics Materiel Processing Center, Ogden Air Materiel Area, Hill AFB, Utah. The Center is presently under construction.

dling systems within the existing buildings. While productivity has improved, the potential has not been realized. The layout of efficient systems for the production type functions of receiving, packaging and shipping has been restricted by the use of structures designed for World War II concepts of storage and operations. Seventy-eight percent of the depot warehouses are over 25 years old with low stacking heights and configurations that limit efficiency for use with either modern processing or automated storage systems.

To gain the productivity required of the future, the design of new facilities must provide for totally integrated systems. There is no apparent limit to the size of a single warehousing complex. It should be of single story, multifunctional design capable of housing all the processing operations, with high-rise automated storage retriever systems integral to the facilities or adjacent to them. Application of this concept at existing depots can be made by constructing processing centers adjacent to major storage facilities for direct conveyor tie-in.

The results of the task group's analysis of material flow patterns indicate the most efficient arrangement of operations within the facilities will be to have the receiving and shipping subsystems adjacent to each other with the packaging, bin, rack and bulk storage fanning out from the receiving and shipping operations in that order.

Technological Applications

The modernization concepts reflected in two model configurations developed rely primarily on the advancing technology in five areas:

- Process control computers.
- Automatic sensing, character reading and marking devices.
- Automated packaging systems.
- Automated storage systems.
- Mechanized materiel movement.

In the processing functions, conveyor handling systems have been used for several years to reduce the labor involved in physical handling. The opportunity for major productivity improvements in these areas lies in eliminating the manual tasks involved in processing paperwork and the interface with the automated data systems. Preservation, packaging and packing are also highly labor intensive areas consuming 30 to 56 percent of depot warehousing labor. The movement of items to and from the storage locations is another area where significant potential improvements can be made by applying the technological developments of recent years.

The task group selected two depot sizes for use in configuration of the proposed depot storage facility. A peak theoretical workload (30,000 materiel release orders per day), approximately 100 percent higher than the most active existing depot, was selected as one level. This corresponds to a size of approximately 1 million FSN items in storage. This level of activity and volume of storage might involve a stock composition which would effect greater centralization of bin-type stock in selected depots. Such major depots could have peripheral annexes containing principally bulk stocks and slower moving items. A relatively low theoretical workload volume (3,000 materiel release orders per day), corresponding to approximately 100,000 FSN items in stock, was selected as the second level. By constructing the conceptual system models in these two widely separated ranges, in-between workload situations can be accommodated by extrapolation.

The task group's analysis of models for the two sizes of depots indicates that economical use can be made of a significant portion of the new technology, regardless of whether or not further study of the DOD distribution system indicates that a few large depots or a larger number of medium size depots are desirable.

Proposed System Operation

The terminal operations in the proposed depot facility will make extensive use of on-line optical character and code readers and laser or video jet automatic markers to accomplish much of the processing tasks. The receipt process starts with the input of the carrier delivery documents to a process computer using an optical character reader. As each container is offloaded, sensors along the conveyor will automatically verify the receipt against the carrier information. The computer will automatically mark the containers for subsequent routing. The single item containers and single item trays from the consolidation tray out stations will pass through stations where the complete information needed to establish the receipt will automatically be put into the computer. The computer will determine and code the containers or trays for subsequent routing including the specific storage location. Items which require sample inspection or exception processing will be coded for routing to other appropriate stations.

The approach conceived for modernization of the packaging operations makes extensive use of developments underway in the automated packaging field. The task group has proposed a mid-range as well as a long-range plan for the mechanization and ultimate automation of packaging operations. The long-range plan envisions computer control of the process with a bank of machinery available to accommodate the varied sizes, types and shapes of items in stock. High-quality protective barriers of common purpose capabilities will supplant the numerous wrappings and preservatives used now.

Two competing technologies are envisioned for use in modernizing the storage operations. Automatic Retriever Storage Systems will be used to service the more actively used bin and rack stock within the major depot complexes. These systems, which retrieve the bin containers or pallets from the location automatically, will virtually eliminate the high labor intensive operation of moving between locations to pick, store or accomplish other custodial transactions. The analysis indicated that these systems can be economically installed as high-rise storage (up to 100 feet) units adjacent to the processing subsystems. The rack structure can be used to support both the walls and roof of the facility.

Computer controlled stock picking vehicles are also proposed for use in servicing the less active rack stock and within existing conventional warehouses with lower stack heights. These systems, while not eliminating the movement of personnel in the aisles, provide a highly efficient method of tying the manual picking tasks to the computer. The computer, essentially, optimizes the movement of the vehicles and tells the operators what tasks to perform, with on-line response of actions completed.

Implementation

The series of studies completed by the DOD Logistic Systems Policy Committee Task Group 5–70 confirmed the need for establishment of a modernization program for DOD logistic storage facilities. While there are still many aspects of the logistic storage system which need evaluation and study, the task group recommended these actions for consideration by defense logistic managers:

- Give consideration to storage facility modernization similar to that provided the weapon system acquisition process.
- Use existing programming models to assist in determining the optimum modernization program for the storage system of the 1980's.
- Initiate development projects as necessary for the modernization of storage facilities.

Phase III of the task group's effort, which will lay the groundwork for implementation by DOD and its components, has been initiated. Some new programming models have been developed which are expected to aid in better defining future facility needs.

A very flexible simulation model has been developed to allow analysts to study the impact of a large number of specific labor and non-labor costs on the annual operating expenses of a large storage depot. When such depot cost factors and their behavior are better understood, the analysis team plans to return to the transportation model and more closely define the optimal economic capacity of future super depots. This refinement is not expected to significantly change earlier study findings which defined capacity for the proposed storage facilities of the future; instead, it is designed to provide better definition of these facilities.

Another programming model is geared to handle estimates of different numbers and types of material handling equipment associated with modernization proposals and also incorporates estimates for building structure costs across a wide range of sizes. The preparation of the model permits the analysts to study several alternative configurations and have some common measures and a common basis for comparing the alternatives.

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A third model is designed to accept the investment outlays in dollars along with dollar savings taken from the simulation model. An array of financial measures can then be projected with the intention of providing the decision maker with estimates of the required investment dollars for alternatives such as net present value for varied system configurations, return on investment accorded to each alternative, and distribution of the estimated years to pay back the original investment with savings.

The modernization of logistic storage facilities should be developed without delay to provide a fully capable, flexible and financially supportable storage system for the 1980's. ☐

ACKNOWLEDGEMENT: The author expresses his appreciation to all members of Task Group 5–70 for their contributions to this article.

DSA Expands Mill Run Products Program

The Defense Supply Agency (DSA) is expanding its Mill Run Products Program to assure that certain basic materials used by the Department of Defense and its contractors are available when needed.

The program, begun in 1971 to assure the availability of basic aluminum materials such as extrusions, drawn tubing, rolled and furnished rod and bar, sheets and plates, is now being expanded to include other commodities with emphasis on electronic parts and devices. Manufacturers are being encouraged to produce, in quantity, microcircuits, digital microcircuits and resistors in accordance with appropriate military specifications.

In addition, the Air Force Space and Missile Systems Organization is preparing specifications to cover other preferred parts families of solid state devices, such as power transistors, which are expected to be future candidates for the program.

Under the Mill Run Products Program, participating manufacturers enter into an agreement with DSA to manufacture and stock materials on the basis of experience and projection of future DOD needs.

Under the agreement, a company:

- Produces and controls the quality of the material in accordance with applicable military or Federal specifications.
- Performs inspections and tests in accordance with specifications and maintains records for review and verification by Government quality assurance representatives.
- Maintains an inspection system in accordance with military specification MIL–I–45208A or a quality system in accordance with military specification MIL–Q–9858 depending on the product.

Industrial participants in the program may withdraw at any time and, while participating in the program, are not required to deliver exclusively to Government users. Materials may be sold in the commercial market even though they are marked to indicate they have been manufactured to military specifications. There is no obligation on the part of the Defense Department or DOD contractors to purchase any of the manufactured items.

Some of the benefits of the program are:

- Participating companies will have Government inspected stock ready for immediate delivery when a requirement arises.
- Contractors can quickly obtain materials which have been inspected and tested in accordance with applicable specifications and are in stock.
- Paperwork can be reduced since the need for Government endorsement of a contractor's shipping documents would be eliminated.
- Verification time will be reduced since large lot production will practically eliminate piecemeal inspections of numerous small quantity purchases.

Additional information on the Mill Run Products Program may be obtained from Defense Contract Administration Services, Defense Supply Agency, Cameron Station, Alexandria, Va. 22314; or from the Quality Assurance Directorate of any Defense Contract Administration Services Region. ☐

To Change Is the Future

If the federal government is to meet the rapidly changing demands of today's society, we must not only develop sound policies, but we must also possess the capacity to implement our policies quickly and effectively. All too often, however, we find that it takes weeks or months for a decision made by the President, Congress, or a department head to result in action. Much of this delay is unnecessary and must be eliminated.—Richard M. Nixon

The problem of productivity has always plagued industry and Government organizations. All organizations that have existed for any length of time have attained a position of equilibrium and balance. Interests have been co-mingled and integrated, relationships have been established and routines developed which may or may not be productive. The work force usually perceives its present *modus operandi* and work layout as being the best way. Management's responsibility is to continually evaluate performance and determine if there are better ways to do the job.

In a sense management effects change, seeking to produce conditions and behavior which would not have otherwise occurred. However, rapidly accelerating technological, political and economic changes throughout the world require the individual Government department or business enterprise to be highly efficient in introducing and accommodating internal technological and organizational changes. The goals of the organization, its structure, the design of its systems, and the management of its processes must all be amenable to change if it is to succeed.

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There is no right way to manage an organization; rather, proper management depends on several factors but, most importantly, the fit between management's assumptions about people and those of the organization. This fit or "psychological contract" between the individual's rights, expectations, privileges and obligations and the organization's goals and objectives should be equated and balanced by the authority system. The manager, who attempts to change his employees' behavior by drastically changing existing procedures, may succeed only in alienating himself from the rest of the organization. Unless he sees the indispensable necessity of commonly shared beliefs about appropriate organizational behavior and the need to work within that framework, he will invariably meet resistance, hostility, suspicion and ostracism.[1]

Complex Factors

Resistance to change by itself is neither good nor bad and may or may not be soundly based. It is, however, an important signal requiring investigation by the appropriate level of management. Actually, what employees resist is usually not technical change but social change—the change in their human relationships that generally accompanies technical change.[2]

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[1] *Katz, Robert L., "Toward a More Effective Enterprise,"* Harvard Business Review, *Sept.–Oct. 1960, pp. 80–107.*

There are several complex factors that influence resistance to change. If a manager could forecast these resistant attitudes or feelings, he could plan successfully for the change. The principal reasons for resisting change (or conversely the positive aspects for accepting change) are fear of:

- *Economic Losses:* The individual may be asked to do more work for the same pay; opportunities for advancement may be reduced.
- *Loss of Personal Security:* Doubts may exist about the ability to learn a new technology or new skills; the change may create surplus personnel with a subsequent loss of jobs.
- *Increased Personal Inconvenience:* The new conditions of work (environment, location, travel, working schedule) may be more difficult or less pleasant.
- *Decreased Job Satisfaction:* The pressures of the job may be different, the new situation may be more restrictive and the supervision may be greater.
- *Loss of Status:* The change may damage relationships with customers and other persons outside the organization.
- *Manner of Change:* The change may be accomplished too hastily and handled forcibly.
- *Infringement on Cultural Beliefs:* The change may be inconsistent with the worker's beliefs or known truths.[3]

The key problem in making any change is how to minimize resistance by those involved in whatever form it may occur. These forms can and do vary widely, ranging from active aggressive resistance through more subtle passive resistance to acceptance. The manager must be able to anticipate resistance and estimate its intensity. More important, he must also anticipate the root of its causes and reasons. By understanding these relationships and how they interplay, any manager should be able to plan and implement changes which will minimize resistance and transform it into some form of acceptance.

Success in Making Changes

It is both impractical and undesirable to formulate a rigid standard for managers to follow in introducing and implementing any change. However, a number of factors about which managers should be concerned and a suggested order of sequence can be postulated. Broadly, there are a minimum of five phases of managerial action utilized in successfully implementing a change:

- *Analyzing and Planning the Change.* Before taking any action to introduce or implement a change, management should devote some time to analysis and planning. It should anticipate, in as much detail as possible, what effects the change will have organizationally and what problems are likely to arise; work out in advance the more important answers and solutions to anticipated resistance; and develop a milestone schedule for implementing the change. With an adequate amount of preparation, management can greatly improve the probability of acceptance of change by those on whom the ultimate success is most dependent.
- *Communicating the Change.* Management should thoroughly discuss the change and its implications—why, advantages, disadvantages, schedule, methods—with those affected and involved, including the employee union. This communication must be a two-way process. By obtaining a preview of the employees' and the union's reactions to the change, management can modify those aspects which might prove objectionable or introduce compensating factors. The intensive program of communications should begin with the completion of the analysis and planning stage, and continue in varying degrees until the organization's objectives are met. No doubts should be allowed to persist about the desirability or inevitability of realizing management's objectives. However, the actual methods for accomplishing the change should first be perceived as proposals, subject to alteration and modification. Such flexibility is essential if those involved are to believe their comments and suggestions will be considered seriously.

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[2] *Lawrence, Paul R., "How to Deal with Resistance to Change,"* Harvard Business Review, *Jan.–Feb. 1969, pp. 4–12.*

[3] *Judson, Arnold S., "A Manager's Guide to Making Changes," New York: John Wiley and Sons, Inc., 1966.*

- *Gaining Acceptance of the Required Changes in Behavior.* The changes necessary for the transition are determined by the particular methods (persuasion, rewards, penalties, negotiation, participation) management selects to accomplish the desired objectives. Whatever approach management takes, its effectiveness depends on how much discussion takes place. Inevitably special personal problems will arise. Whenever exceptions and modifications are made to accommodate individual needs, these can be understood and accepted by a group if it perceives these exceptions as reasonable.

- *Making the Initial Transition.* After the methods of making the change have been confirmed and previously mentioned facets are completed, the change should be accomplished on a scheduled basis with time allowed for unforeseen problems. If new knowledge and skills are required by the change, training activities should be designed and implemented in milestones. Often, the managers, and especially the first line supervisors, have as great a need for both briefing and training as do the operatives, staff and union. During the transition period, management must be kept continually informed of the progress. Firsthand involvement of sufficient frequency with the staff and operatives is most valuable to truly assess the viability of success.

- *Consolidation and Follow-up.* To ensure the objectives of the organization impacted by the change are met, management must have a systematic follow-up system. It must be alert to unexpected effects and must ensure that both the results of the change and the way in which they were achieved are evaluated completely and objectively. Too many times a change is instituted, things look good, and the personnel revert to the old method; this is particularly true in staff or administrative type situations. Management can contribute greatly to success if it remains flexible about altering the methods used for realizing the change.[4]

Change Is Normal

Any organization operates within an environment that is continually changing. How much benefit management can achieve from a change is contingent on three variables of skill:

- Identifying and analyzing the objectives of the change and the attendant problems.
- Developing successful methods to accomplish the objectives by solving the problems.
- Gaining acceptance from the employees affected by and involved in the change.

It is necessary that an organization's objectives, policies, structures and methods of operation be modified to achieve and maintain efficient operation and economic vitality and viability. Whether management is implementing its own desires for improvement or reacting to external pressures, the manner in which it attempts to change the present status will determine the long-term growth of the organization. □

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[4] *Ibid., Chapter 9.*

Supply Production Continuity: A Life Cycle Maintenance Improvement

Cost-effective life cycle support for defense weapon systems should be the primary objective of any contractor's integrated logistic support organization. This is particularly true when weapon systems phase out of production and operational military support units lose the benefit of open production capacity.

To assure a source of supply support after production is completed, the production contractor should, in cooperation with the buying military service, provide for a Supply Production Continuity Program. Such a program can be designed to be a practical, timely and economical approach to fulfilling spares and repair requirements for a complex out-of-production system still in DOD's active inventory. The program can also include current thinking within DOD relative to prime contractor participation in planning for weapon systems deployment and their operational support.

by Richard D. Webster
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Opinions expressed herein are those of the author and not necessarily those of the Department of Defense.

A Supply Production Continuity Program, in short, can be a jointly planned effort to provide life cycle support for out-of-production equipment. Its main objective is to provide for a cost-effective solution to spares and repair needs for a weapon system by utilizing the original contractor's facilities and know-how. Both cost and lead-time savings result from such a program. In addition, several other advantages can be realized such as preservation of management and technical expertise, improved mobilization planning, maintenance of system quality and reliability, more efficient facilities loading and faster reaction to emergency requirements.

First Implementation

The weapon system program used for the first implementation of a supply production continuity arrangement was a Navy multi-mode airborne radar. The system consisted of 30 replaceable system assemblies, the majority of which were mounted in the nose section of the aircraft with the remaining units in the cockpit area, and about 30,000 discretely different parts.

The radar system was provisioned in its original production configuration in the mid-1960's. Of the 30,000 different parts in the system, 3,000 were source coded as procurable spare parts and were further subclassified as 1,200 design contractor source and 1,800 common vendor items. From the beginning, the 1,800 common items were placed under the management of the Defense Supply Agency; the remainder were retained for supply management by the Navy.

The 1,200 Navy-controlled items consisted of about 300 repairable assemblies and 900 consumable parts. Since then, as a result of configuration changes and further break-out actions, the total sole source listing given to the contractor now contains 253 repairable items and 400 consumable parts. It is the life cycle supply and repair of these items that is involved in the Supply Production Continuity Program.

Over 750 of the radars and associated replacable spare system assemblies were delivered by the production contractor to the Navy and a foreign government during the late 1960's. During the first two years, the support of delivered equipment was provided for by the contractor under a contractor support specification. After that, the systems were supported by DOD. The last production system was delivered in 1971 and closure of production lines occurred in December 1971.

During the entire design and production life of the system, the contractor maintained an Integrated Logistic Support (ILS) Management Team which operated under the guidelines of DOD Directive 4100.35, "Integrated Logistic Support Management," and, during production phase, was an effort funded by the system program. Since closeout of production, ILS has been continued and funded by the overheads of the various system support products bought by the Navy.

The ILS Management Team is still active and supply production continuity will be the primary funding source to preserve this and other required technical expertise over the operational life cycle of the equipment.

Start of Supply Production Continuity

The contractor ILS Management Team had worked actively with all support elements of the Navy to provide timely, effective support for the radar systems dating back to program start up. Many problems occurred in assuring adequate support during the production buildup phase which, through joint Navy and contractor efforts, were solved and fleet support was provided without degradation. This type of cooperation during system production phase set the stage for subsequent problem solving of out-of-production systems before the problems became serious.

The key problem appeared to be cost-effective supply support after production close out. Since the foreign government version of the radar system went out of production one year earlier than the U.S. Navy version, efforts of the contractor were directed there. A 7-point support proposal was presented to the foreign government by the contractor indicating benefits which would result from direct, continued relationships with the contractor. The seven areas of benefit were:

- Implementation of a direct purchase agreement for non-Federal stock numbered and out-of-stock items.
- Implementation of an automatic ordering agreement for initial lay-in of changed parts.
- Direct expedite services on unfilled government support orders.
- Reprovisioning to latest configuration and demand data.
- Life-of-type buy on peculiar parts.
- Contractor repair of items.
- Contractor logistic management resident in country.

These areas of support and several others were subsequently contracted for between the foreign government and the contractor in a Post Production Services Agreement.

Support for the Navy System

Later, as a result of the foreign country out-of-production support action, a life-of-type procurement proposal for all contractor-sourced spares was presented to the Navy. At that time, the Navy production contract was scheduled to be completed shortly and the program manager foresaw no new production buys. The proposal was well received but fiscal funding limitations prevented an order of that magnitude for multiyear requirements.

As an alternative, a fiscally fundable proposal was suggested by which it would still be possible to retain some of the benefits of life-of-type procurement by agreeing to an annually renewable spare parts production and repair program. This action resulted in a Supply Production Continuity Program implemented by the Navy.

From the standpoint of spare parts procurement, it has always been accepted that the contractor would continue to provide contractor-sourced items as required. In the case of repair effort for the radar system, the Navy suggested early in the program that the contractor create and maintain a repair capability for the system because of the impending operational support loading problems at the Government depots. The contractor's top management responded by opening a 100,000-square foot spares production and repair depot during production buildup which is completely equipped and manned to provide total maintenance of the system.

Because of these actions and other program needs, both spare parts manufacture and repair effort were included in the supply continuity effort. The contracts under which the procurements are made are two annually renewable basic ordering agreements issued and managed by the U.S. Navy Aviation Supply Office. One is for spare parts and the other for repair modifications. Navy requirements for both spare parts and repair are received annually with renewable contractor sole source listing for the planned spare parts procurement.

With this data and in-house ILS experience, the contractor plans facility and manpower loading which will supply the planned demand at minimum cost and lead time in consonance with contractual limitations.

Since the supply production continuity effort is in its infancy as a DOD integrated logistic support innovation, much of the activity under this program is being carried out through cooperative agreements between command levels of the Navy and top management of the contractor.

Program Advantages

The basic reason for a supply production continuity arrangement is cost effectiveness. It is estimated that significant life cycle savings in both costs and lead times will be gained by the use of a planned program. On the contractor's part, it is no more than good business sense that motivates management to provide products and services profitably and develop satisfied customers. It is likewise assumed that the Defense Department is also motivated, through sound planning doctrine, to assure optimum utilization of resources to satisfy strategic and tactical objectives.

Aside from the general benefits, there are quantifiable benefits which can be identified. Accurate estimates of savings can only be based on a program for a specific year since significant changes in loading would affect any projection. An annually planned program has been evaluated to show a savings in cost for spares and repair of 20 percent over unplanned support. In other words, additional costs such as production start-up, source investigation, retooling, test equipment renovation, configuration authentication, increased set-up charges, worker familiarization and additional material procurement charges would drive the total cost of this effort up considerably.

The largest economic benefits come from the ability to maintain open testing capability for both spares and repairs. Keeping a stable work force of qualified personnel continuously working with up-to-date equipment provides low cost, high quality response to any and all needs for hardware.

The second quantifiable benefit is production lead time. In a production closeout situation, lead times increase when open, active production capability is lacking. Generally, this lead time increase ranges from 25 to 50 percent. Lead time is important to both the military service and the contractor because it represents money. Procurement funds and working capital are tied up for longer periods in an unplanned program. In addition, laid-in stock levels must be increased to make up for delivery delays and, of course, ability to expedite high priority needs of both spares and repairs disappears without open production capacity. A planned support program should mean an additional savings of many dollars in lower total inventory and capital required for progress payments.

In addition to the quantifiable savings of supply production continuity, other benefits are derived by both DOD and the contractor:

- *Expertise Retainment.* By continuing a funded program, the contractor can retain a team of both management and technical personnel who are available to help solve any future production or support problems.

- *Mobilization Base.* Supply production continuity is an ideal total solution to mobilization requirements for first line weapon systems as specified by DOD Instruction 4005.3M which encourages maintenance of "hot production lines" as a trade-off to the alternative of providing larger quantities of pre-M-day stocks.
- *Reduced Organic Maintenance Costs.* The need for some of the in-house facilities, equipment and personnel, as well as their upkeep, will diminish since they can be diverted to tasks more critical to the tactical environment.
- *Reduced Supply Inventory Management.* The overall supply management budget, including cost of stock, can be diminished or diverted to other needs in those areas where contractor stocking has provided for material previously stocked by DOD depots.
- *Modification / Refurbishment Capability.* The contractor depot is designed to provide modification and refurbishment effort. As need arises to update equipment or to overhaul old equipment, it can be done at no increase over normal recurring costs.
- *Foreign Government Cooperative Logistic Support.* As previously stated, the ILS commitment of DOD to a foreign buyer is carried out to a large extent by the availability of contractor sole source spares. Assurances of continued availability of the high quality level received from the contractor, accompanied by the special expediting services, go a long way toward satisfying the customer.
- *Future Procurements.* Although there may be no planned buys of production systems, the world situation may dictate some additional production requirements. The ability to respond to a need on a timely and economical basis will be greatly enhanced by "hot production lines" for supply items. Production capacity for the major portion of the system is already in being.

One More Milestone

Supply production continuity arrangements could possibly save DOD millions of dollars through the operational life of most weapon systems. It should also be a vital part of future policy for maintaining the active out-of-production weapons inventory in times of tight DOD budgets and peacetime economy.

The Defense Systems Acquisition Review Council (DSARC) should consider an additional DSARC decision point at "weapon system production closeout." At this additional decision milestone, the production contractor and the military service procurement agency would be required to submit a joint plan for out-of-production support until system retirement.

This is a vitally needed management improvement to the DOD system acquisition policy, particularly in a peacetime environment. Both the military services and their supporting defense industries have a requirement for better life cycle costing which must consider system effectiveness and reliability. ☐

All free governments are managed by the combined wisdom and folly of the people.
—President James A. Garfield

U.S. Defense Communications Requirements Can Benefit from Leasing Foreign Systems

Foreign communication facilities that might be used to satisfy U.S. defense requirements encompass a wide range of communications systems. Methods used to meet these requirements include lease of commercial systems in countries that offer communications services and facilities, design of Military Assistance Program (MAP) communications projects in many countries to meet existing or future requirements, and use of existing or planned multinational military communications systems. NATO communications systems constitute a prime example of the third category.

Under policy stated in the Office of Management and Budget Circular A–76 and DOD Directive 4100.15, DOD operates and maintains its own communication facilities within the United States only where:

- Satisfactory commercial communications are not available or use of them would disrupt or materially delay a program.
- DOD facilities are required to maintain a personnel or mobilization capability.
- The cost of commercial communications would be greater than equivalent military communications. A 10-percent higher cost factor is generally employed as a threshold.

by Maj. Gen. Robert D. Terry, USA
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Implementing this policy, DOD spends $300 million annually leasing communication services in the United States. Seventy-six percent of the Defense Communications System in the United States is leased from commercial carriers, clearly indicating that DOD communications requirements in the United States are heavily dependent on commercial leases.

Overseas, current DOD policy seeks to assure adequate interoperability of defense communications with those of other countries where U.S. forces are based, to be determined on a case-by-case basis with built-in safeguards for security and end-to-end connectivity. The policy is not limited to commercial communications but includes the whole scope of foreign communications capability as previously outlined.

The United States is now leasing significant services and facilities from foreign communications companies. Transoceanic cable and satellite circuits from the continental United States (CONUS) are leased by the Defense Communications Agency's Defense Commercial Communications Office (DECCO) from U.S. companies providing international communications services. On each circuit the U.S. company acts as the DOD agent and pays a foreign company for that part of the circuit from its geographical mid-point to its termination in the other country. Presently, DOD leases approximately 260 such circuits at an annual cost of $23.9 million.

DECCO, through its field units in Hawaii and Europe, leases directly from foreign companies private lines which do not have a service point in CONUS. For example, DECCO-Europe leases about 3,000 circuits and related equipment at an annual expenditure of $13.6 million in 18 countries.

The military departments also lease communications in some parts of the world. For instance, in Japan the Air Force annually leases private lines for about $1 million and operation and maintenance services for about $5 million. The Army administers a centralized leasing function in Okinawa, Korea and Thailand; however, the leasing dollar amounts are somewhat lower. These figures are cited to illustrate DOD's reliance on commercial communications systems in foreign countries as well as in the United States.

Advantages

In a highly developed country such as Japan, the annual direct cost of stationing a noncommissioned officer there is currently about $9,000. Annual direct cost for a DOD civilian employee is about $14,000. A communications system, owned and operated by DOD, normally requires several full-time military or civilian operation and maintenance attendants at its terminals and major nodal points. On the other hand, a communications group of 12 telephone voice channels can be leased in Japan from Itazuke to Sasebo, a Navy base on the west coast of Kyushu, for $32,700 a year.

One of the antennas of a Nippon Telephone and Telegraph Public Corporation antenna tower supports a leased broadband system between Itazuke and Sasebo.

Where an adequate communications network exists and is available for use over a relatively wide area, installing, removing and reinstalling U.S.-owned equipment are not required to meet changing conditions. It is a much simpler operation to start and disconnect a leased service. This arrangement provides budgetary and operational flexibility since the need for large capital investments and plant equipment is eliminated. Considerable latitude exists in the use of funds for leasing, permitting rapid adjustments without the necessity for long lead time and planning actions.

The operating manpower which can be obtained through the use of foreign communications is manpower that does not have to be provided by the military services. While manpower estimates are vague and subject to considerable interpretation, if we make the simple assumption that the operating and maintenance manpower of the military departments compared with the Government owned and operated systems is proportional to the civilian manpower required for the leased portion, then by leasing we save something of the order of 33,000 men per year. Since this estimate is based solely on leased systems and does not include the use of multi-national or MAP systems, it is probably conservative.

Disadvantages

During recent years, while building and operating an extensive and sophisticated modern communications system in the Republic of Vietnam and Thailand, experience showed that under certain conditions civilian contractor personnel can operate fixed communications systems in a combat zone. Tactical communications, however, must be highly mobile to assure responsive communications support for mobile tactical forces, and to permit the establishment, realignment and relocation of entire communications systems within a few hours. Generally, leased services cannot meet mobility and responsiveness requirements. This, then, results in significant limitations in the tactical application of leased communications.

Leased communications are usually provided in terms of a specified quantity and quality of service between two designated points. Generally, DOD has no direct control over the personnel or the facilities providing that service. A strike by a communications workers union or a change in the foreign policy of the home country of a foreign commercial or quasi-commercial company could conceivably cause a serious lack of communications. The key factor that must always be recognized and met is the need for command and control of deployed U.S. forces; consequently, adequate integral communication capabilities must be built into these force structures.

Availability

A significant range of communications capabilities is available around the world. Japan has a highly developed telecommunications complex with 29 million telephones and a ratio of telephones of 28 per 100 population. This compares with a similar ratio in the United States of 60 per 100 and in the United Kingdom and the Federal Republic of Germany of 28 and 24 telephones per 100, respectively. Japan's telephones are supported by adequate switching facilities and very extensive cable and modern microwave networks. In fact, the Nippon Electric Co. is already employing quadrature phase shift keying (QPSK) for digital transmission over some systems.

On the other hand, the Government of Turkey operates a relatively sparse communication system providing an estimated 654,000 telephones for a ratio of 1.79 per 100 population. Yet, even in this underdeveloped national system, the United States is leasing eight circuits at an annual cost of $150,000.

NATO Systems

In addition, there are key multi-national systems that are being used or could be made available to meet U.S. defense needs. For example, the NATO Ace High system is basically a 60-voice channel tropo/microwave system of 50 main links serving major NATO commanders and their primary subordinates throughout the European NATO region from northern Norway to eastern Turkey. Ace High, in existence since the mid-1950's, will be upgraded and combined with the NATO Integrated Communications System (NICS).

NICS is planned to be a sophisticated, circuit-switched system embodying a satellite space segment, satellite ground terminals, operational message distribution centers and switching nodes/gateways. It will provide communications for the NATO Headquarters, the major NATO commands and the NATO civil wartime agencies. Clearly, this is a network with much potential for U.S. defense use. To enhance this potential, the Defense Communications Agency has established the Defense Communications Field Office, collocated with the NICS Management Agency in Brussels, Belgium, to promote interoperability between NICS and DCS.

Future Requirements

In addition to the categories of communications previously mentioned, communications capabilities exist in foreign countries installed under MAP or the foreign military sales program. Until recently, no coordinated effort had been made within the Defense Department to review these programs and make selected systems compatible with DCS. The need for this compatibility rests on the premise that in a variety of circumstances communications could be extended to meet U.S. requirements by leasing rather than developing new systems, thereby reducing U.S. expenditures in dollars or manpower resources.

Positive steps to promote DCS compatibility are being taken. In coordination with the Director of the Defense Security Assistance Agency, the Defense Communications Agency is reviewing ongoing and projected projects with the military departments. So far, an Air Force project in Greece, an Army project in Korea, and a Navy-sponsored effort in Saudi Arabia have been examined. Approximately 18 additional systems which have been recently installed or are presently in the process of implementation will be examined. New projects will be reviewed as they surface to ensure the communications systems designs are consistent with DCS system objectives.

The use of foreign communications to satisfy U.S. defense requirements is a valuable and important technique. U.S. defense planners and managers should consider the advantages of foreign systems to satisfy defense communications requirements. ☐

a few words about...

Hazardous Materials Vehicle Accepted by Air Force

A new remote control vehicle system has been accepted by the Air Force Systems Command's Armament Development and Test Center, Eglin AFB, Fla., for use in handling hazardous materials at the Center's test ranges.

The system, consisting of a small tracked vehicle and a self-contained control trailer, is completely mobile and can be set up in approximately 30 minutes. The operator controls the vehicle by means of a dual camera lens system. The two lenses, a foveal and a peripheral, are side by side and display two images to the operator. The direct view presents a clear image while the peripheral lens presents a wide angle view of the entire area. By combining the two images the operator can recreate the same picture that would be seen by the human eye.

Other technical equipment in the system includes a radio frequency command data link, a radio frequency video feedback data link (television), a communications link, an auxiliary power system and a hydraulic pump system. The system is modularized to allow installation and operation of select parts in a variety of military vehicles.

After completion of testing, manipulator arms will be added to allow the vehicle to locate and disassemble live munitions up to five miles from the control trailer.

Air Force remote control vehicle undergoing test and evaluation at Eglin AFB, Fla. Following testing, the vehicle will be fitted with manipulator arms to perform various functions involving the handling of hazardous items.

DSA Assumes Property Disposal Function in RVN

The Defense Supply Agency (DSA) has assumed responsibility, previously assigned to the Department of the Army, for disposition of DOD foreign excess personal property in the Republic of Vietnam.

DSA's Defense Property Disposal Service will manage disposal activities in Vietnam through its Pacific Region and will maintain a small sales office in Singapore.

The Defense Property Disposal Service was established in 1972 to provide a single organization responsible for the utilization and disposition of DOD materiel. Proceeds from the sale of surplus materiel in FY 1973 amounted to approximately $118 million. Monies from the sale of property are used to pay the expenses of the program with the remainder being returned to the U.S. Treasury.

Admiral Moorer Receives Forrestal Award

Admiral Thomas H. Moorer, Chairman of the Joint Chiefs of Staff, has been awarded the 1973 James Forrestal Memorial Award of the National Security Industrial Association.

The James Forrestal Memorial Award has been given annually since 1954 to outstanding Americans whose leadership has promoted significant understanding and cooperation between Government and industry. Previous recipients include President Dwight D. Eisenhower, Robert S. McNamara, David Packard and James S. McDonnell.

Admiral Moorer was given the award for exceptional service to the Nation throughout his military career.

SES Inventor Receives Award

The David W. Taylor Award for Scientific Achievement has been awarded to Allen G. Ford, an aerospace engineer at the Naval Ship Research and Development Center, Bethesda, Md.

The award, given annually to the scientist whose contributions are considered most outstanding in the field of research and development, was presented to Mr. Ford for his achievements in the field of advanced ship development. Mr. Ford is credited with the invention of the Surface Effect Ship (SES) and holds six patents on SES development.

ASQC To Hold Tech Conference

The 28th annual technical conference of the American Society for Quality Control will be held May 20–22 at Boston, Mass.

The international conference will feature applications of technologies, communication and management skills and impact subjects related to industrial groups.

Further information on this and other ASQC conferences may be obtained from the American Society for Quality Control, 161 West Wisconsin Ave., Milwaukee, Wis. 53203.

Army Improves Runway Light Set

A new runway light set for use at night and during times of restricted visibility has been developed by the U.S. Army Mobility Equipment Research and Development Center, Ft. Belvoir, Va.

The most significant improvement is a small, economical bypass circuit assembly to replace the power isolation transformer currently used. It is estimated the new sets will save $1,200 per unit over present light sets.

Senator Proxmire Praises Army

Senator William Proxmire (D-Wis.) has praised the Army for substantial savings achieved through its capital investment program.

In a statement on January 8, Senator Proxmire cited 24 capital investments at the Army's Ammunition and Supply Agency in Joliet, Ill., which cost approximately $500,000 and saved $1.8 million in the first year. He said this was an example of what the Defense Department could do to cut down on waste.

"For years I have been critical of waste in the military," said Senator Proxmire. "It's great to find a military program that has turned out to be a gold mine for the taxpayer. As one of those leading the charge against military waste, I am happy to eat humble pie in this case and admit that the Army has done a superb job for the taxpayer. . . ."

Business Management Research Center Opens

The Air Force Business Research Management Center (AFBRMC) was recently established to find new ways of doing business and achieving cost reduction and efficiency by Air Force contractors.

The Center, located with the Air Force Institute of Technology (School of Systems and Logistics) at Wright-Patterson AFB, Ohio, is striving to combine research efforts of military and civilian educators and industrial researchers in matters concerning defense procurement.

Through joint cooperation AFBRMC hopes to harness the talent of governmental, industrial and academic communities to develop new approaches to defense procurement and stay abreast of advancing technological and economic conditions.

Army Films Win Management Awards

Five Army films have won awards at the 1973 Film Festival of the Industrial Management Society. Three films from the Office of the Comptroller of the Army took first, second and third place in the management techniques category. The films, "Make Fewer Motions," "Road Map to Less Effort" and "Take Fewer Steps," were produced as part of the Army's work simplification program.

"Bridging the Gap," produced by Edgewood Arsenal, took first place in the methods improvement category; and "Aircraft Ground Safety," produced by the U.S. Army Missile Command, received honorary mention in the management techniques category.

AFCEA To Hold Convention on Communications

The Armed Forces Communications and Electronics Association will hold its 28th annual convention June 11–13 in Washington, D.C.

The convention, titled Communications-Electronics: The Innovative Force, will feature panel discussions by military, industry and Government communications experts covering current and future demands of telecommunication and military communication systems.

Further information on the convention may be obtained from the Armed Forces Communications and Electronics Association, Skyline Center, 5205 Leesburg Pike, Falls Church, Va. 22041.

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